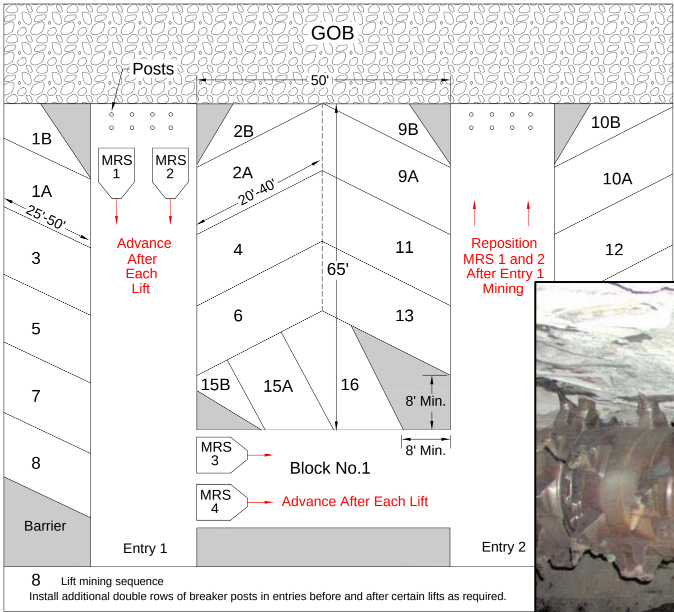
Retreat Mining Practices in Kentucky

A Comprehensive Analysis of Retreat Mining Operations in Kentucky including Regulations, Safety Practices, and Operator Reporting

February 2006



Christmas Tree Retreat Mining Method

Continuous Mining Machine

Prepared for:

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Executive Summary

Introduction

Kentucky suffered four mining fatalities between June 2004 and August 2005, during retreat mining operations in Eastern Kentucky mines. In response to these fatalities at mines practicing retreat mining in the Eastern Kentucky coal field, the **Kentucky Department for Natural Resources *(KYDNR)*** requested an independent study of retreat mining practices. The study was to review active mining operations to ensure that companies engaged in retreat mining are using the best technology currently available and that the current available employee training programs afford maximum safety to miners.

Despite the fact that room-and-pillar mining is one of the oldest methods used for the extraction of coal, the nature of coal mining has changed in recent years. The mining of more difficult and more complex coal seams has brought about innovations in technology and equipment, where additional precaution, heightened safety awareness, and additional training are necessary to eliminate roof fall accidents that result in injury or the loss of life.

In this study, the Researchers evaluated 34 coal mines in Eastern Kentucky that were actively conducting retreat mining operations. In Eastern Kentucky, it is estimated that there are over 100 mines with approved plans to conduct retreat mining, and these mines produce between 33 and 50 percent of the 52 million tons of underground coal mined each year. The importance of this production to the economy of the Commonwealth and the counties where it is mined is significant, and it must be mined safely.

The Researchers have conducted and have completed the following tasks in evaluating the safety of current retreat mining practices:

- Evaluated Current Retreat Mining Methods
- Evaluated the Types and Effectiveness of Supplemental Support Equipment
- Reviewed the Roof Control Plans of Active Mines

- Determined the Impact of Geologic Conditions
- Evaluated Current Training Requirements
- Evaluated Practical Methods to Maximize Safety
- Reviewed Current Kentucky Statutes and Regulations for needed changes

The Researchers recommend changes in the content and review of roof control plans to identify geological conditions and operating practices that require additional safety during retreat mining, and in task training requirements to address the changes that have occurred in the industry and to raise awareness and training of miners to a higher level that will improve safety. Based upon nature of these recommendations, the Researchers believe that these implementations can be accomplished within the current administrative regulations, and believe no legislative action is required. The recommendations detailed in *Part 8.4* of this report are summarized below, and are grouped into three categories: changes to the roof control plan, changes to the amount of geological information required, and changes in the training and retraining of miners.

1. Changes to Roof Control Plans

- **Minimize Workers Near the Active Pillar Line**

Minimizing the number of personnel near the active pillar line should be a primary goal in the review and approval of all retreat mining plans. The use of mobile roof support (*MRS*) units, where height permits, should be encouraged to move equipment operators away from the active pillar line and to remain under supported roof.

- **Coordinate MSHA and State Plans**

Complete implementation of a dual review and approval of the roof control plans by the Federal **Mine Safety and Health Administration (*MSHA*)** and the **Kentucky Office of Mine Safety and Licensing (*KYOMSL*)**. This will eliminate the need for mine operators obtaining separate approvals of roof control and retreat mining plans from two agencies and eliminate the potential conflict of having two different plans.

- **Require ARMPS Calculations in Roof Control Plans**

Require roof control plans to report pillar safety factors and the **National Institute for Occupational Safety Health (*NIOSH*)** Analysis of Retreat Mining Pillar Stability (*ARMPS*) safety factors in all retreat mining plans. Pillar strength and roof stability are directly related and should be considered in establishing a retreat mining program, and ARMPS is critical in establishing the stability of any retreat mining configuration.

- **Acquire Additional Information on Over/Under Seam Mining**

Of the 34 currently active Kentucky retreat mining plans reviewed, 10 mines had abandoned or inactive mines less than 200 feet above or below the proposed retreat mining plan. The plans should include additional geological assessment of the intermediate strata when abandoned or inactive mines are within a specified interval. In addition, mine operators should provide interval contours to the overlying or underlying mine works when abandoned or inactive mines are within a specified interval. A definitive interval or interval criteria to initiate such additional reviews has not been defined due to a lack of research information on the topic. MM&A would recommend a minimum interval of 100 feet or 20 percent of the overburden depth as possible criteria for additional geology, mapping, and technical reviews.

- **Increase Requirements When Mining Includes the Pushout Stump**

As demonstrated in some of the convergence studies presented herein, removal of the pushout stump exposes the intersection adjacent to the pushout stump to a broader spectrum of roof impacts than any other retreat mining practice or pillar lift. The decision to mine or leave the pushout stump is a function of the roof geology, roof lithology, retreat mining method, primary roof support, and extraction sequence. The minimum size of the pushout stump should be established, and its size should be enforced by requiring all operators to measure and mark the length of the stump on its exposed side in the intersection. Mine operators should define the immediate roof geology and install supplemental supports in the intersection, specifically when there is a lack of strong rocks in the immediate roof.

- **Allow Variations in Supplemental Support**

Allowing the use of cable bolts as breaker posts provides greater visibility and freedom of access into and away from the pillar line.

- **Restrict Equipment Operators on MRS Units**

All plans should include the provision that designates a single operator of all MRS units operated inby the pillar line. Once an MRS unit is moved outby the pillar line that is under supported roof, then, alternate operators can be designated to move the units for relocation, maintenance, or repair.

Each pair of MRS units should be equipped with a visible load rate indicator that is currently offered as an option by the manufacturer. The load rate indicator will give a visible warning of increasing load, alerting all personnel of a possible impending roof fall. The KYDNR should develop guidelines for the implementation of load rate indicators on MRS units.

2. Changes to Geology Requirements

- **Geology Requirements in Over/Under Seam Mining**

Additional geological information is needed to assess the geologic structure and lithology of the rocks in the interval between overlying and underlying mines. When abandoned or inactive mines are within a specified distance, additional geologic information is needed to assess roof and pillar stability of the active mine. An outline of geology information to be requested and reviewed during the review process is provided in the exhibits attached to the report.

- **Geology Requirements When Removing the Pushout Stump**

Additional geological information is needed to assess the geologic structure and lithology of the immediate roof in the intersection adjacent to the pushout stump, when it is removed during pillar recovery. The ability to remove the pushout stump and maintain safe conditions is subject to the roof geology and should be defined in the retreat mining plan. An outline of geology information to be requested and reviewed during the review process is provided in the exhibits attached to the report.

3. Changes to Training Requirements

- **Training Requirements**

The most common recommendations in fatality accident reports are 1) the need for mine workers to identify geologic hazards during mining, and 2) the misunderstanding or lack of knowledge of mine workers in the roof control and retreat mining plans. Improvements in both of these areas can be accomplished through additional training with appropriate training materials. Additional task training in retreat mining should be required at the start, or restart of retreat mining. This additional training should be emphasized when a mining crew has not conducted retreat mining operations for a defined period of time. If the retreat mining is continuous over the year, then periodic training during the year should reinforce compliance with the roof control plan. This task training should be in addition to the MSHA and State classroom annual refresher training.

- **Improved Training Materials**

Training materials that specifically address retreat mining either do not exist, or are limited to safe mining practice dos and don'ts. The lack of suitable retreat mining training materials is related to the vast number of various retreat mining plans utilized in the industry. However, specific training modules that address various phases of the retreat mining should be reviewed, renewed, and updated for current practice, and current audio visual technology. Training materials should include, at a minimum, the following topics:

- Timbers – Quality Control of Posts
- Teamwork and Coordination of Installing Wood Posts
- MRS Operating Procedures
- Geology and Identification of Roof Hazards
- Proper Roof Bolting Techniques
- Red Zone Delineation of Hazardous and Unsupported Roof Areas

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Part 1. INTRODUCTION

1.1 *Background*

Room-and-pillar mining is one of the oldest methods used for the extraction of coal seams (tabular ore bodies). In this method, a series of rooms are driven on advance using continuous miners and generally shuttle cars while the roof is bolted a short distance behind the face. During the retreat, the same equipment is used to mine the pillars, which allows roof rocks to cave behind the face. To control the cave line, a series of secondary support systems are installed, as mining continues within the pillars.

In Kentucky, the majority of retreat mining is performed in the Eastern coal field, and primarily in the coal seams associated with the Breathitt Formation of the Pennsylvanian series. Since June 2004, Kentucky has suffered four mining fatalities during retreat mining operations in Eastern Kentucky mines. There are currently 34 mines in Eastern Kentucky actively conducting retreat mining operations. The **Kentucky Department for Natural Resources *(KYDNR)*** engaged **Marshall Miller & Associates, Inc.** (***MM&A)*** to conduct a study of retreat mining practices to ensure that companies are using the best retreat mining technology available and that the current available employee training programs afford maximum safety to miners.

The study by MM&A was conducted by addressing the following tasks:

- **Evaluate Current Retreat Mining Methods**
- **Types and Effectiveness of Equipment**
- **Review Various Roof Control Plans**
- **Determine Geologic Conditions**
- **Evaluate Current Training Requirements**
- **Recommend Practical Methods to Maximize Safety**
- **Review Current Kentucky Statutes and Regulations**

1.2 *Nature and Recent History of the Coal Industry*

Coal mined and produced in Eastern Kentucky is consumed primarily by electric utilities and independent power producers, and in 2004 accounted for almost 92 percent of all coal consumed in the United States (*U.S.*). U.S. coal production increased in 2004 by 3.8 percent to a total of 1,112.1 million short tons, a production level still below the 2001 record level of 1,127.7

million short tons. Coal production in the Appalachian Region increased in 2004 by 13.8 million short tons, to end the year at 389.9 million short tons, an increase of 3.7 percent, but still below the 2002 level of 396.2 million short tons. The shift in production to other areas of the U.S. is evident, as the Appalachian Region has not experienced more than three consecutive years of coal production less than 400 million short tons since the early 1970s. The increase in 2004 in coal production in the region was, in part, fueled by the rise in U.S. coal exports (which are primarily produced in the East), and the large increases in spot coal prices in the region that occurred during the year. In 2004, Kentucky increased coal production by 1.3 percent to 114.2 million tons. Although final year-end production and consumption figures will not be available until March 2006, Kentucky, Appalachia, and the total U.S. production in 2005 are expected to exceed 2004 levels by several percentage points in response to increased energy demand and continued resurgence in the European export market.

Estimated Production 2005

	Tons (x 1,000)	**Percent of U.S. Total**
Retreat Mining [1]	16,199	1.4%
Eastern Underground	**51,869**	**4.6%**
Kentucky	116,530	10.4%
Appalachian	390,037	34.9%
East of Mississippi	485,535	43.4%
U.S. Bituminous Total	1,118,078	

[1]Tons from only 34 mines studied.
Source: EIA Weekly Coal Production Overview 12/31/05

Although the Appalachian Region and Kentucky will produce more coal in 2005, the production level remains constrained by several factors. Transportation problems affected the amount of coal moved to markets. Railroads experienced numerous delays, including a shortage of rail cars, and barge shipments were curtailed due to river flooding, lock maintenance, and other transportation constraints. The combination of mining thinner coal seams with higher reject contributed to more difficult mining conditions in the region. In addition, the legacy of environmental lawsuits temporarily slowed the issuance of permits needed to open new mines or to expand current operations, continued to constrain the amount of coal produced. Declining productivity and increasing operating costs also contributed to the limitations in coal production in some Appalachian states.

Eastern Kentucky produced 90.9 million short tons of coal in 2004, of which 52.4 million tons was by underground mining methods. Retreat mining is estimated to account for more than 33 percent and as much as 50 percent of this total. The slight drop in Eastern Kentucky underground production projected for 2005 is in part due to the closing of a few mines, as a result of reserve depletion.

Kentucky Production (x 1,000 Tons)

	2003[1]	**2004**[1]	**2005**
Eastern			
Surface	39,231	38,426	38,004
Underground	52,078	52,445	51,869
Total	**91,309**	**90,871**	**89,873**
Western			
Surface	4,337	4,052	4,621
Underground	17,160	19,321	22,036
Total	**21,497**	**23,373**	**26,657**
Grand Total			
Surface	43,568	42,478	42,625
Underground	69,238	71,766	73,905
Kentucky Total	**112,806**	**114,244**	**116,530**

[1]*Excludes Synfuel*
Sources: EIA Annual Coal Report 2004 and
EIA Weekly Coal Production Overview 1/9/06

Coal is priced and sold to the electric utility industry based on the BTU/lb, and the sulfur, and ash content. As ash content and BTU/lb, which are inversely proportional, can be controlled in the preparation plant, sulfur is the dominant pricing and demand criteria. Air quality regulations, enforced as point source emission standards, mandate a sulfur content of less than 0.6 pounds of sulfur per million Btu (#S/MBtu) for coal-fired generating stations built after 1970 (New Source Performance Standards or compliance coal). Older coal-fired generating stations may burn as much as 2.0 #S/MBtu in sections of the U.S. designated by the Environmental Protection Agency (*EPA*). However, the predominant electric utility market for coal produced is the low sulfur market, which is coal containing not more than 0.82 #S/MBtu, or the compliance coal market designated as coals containing less than 0.6 #S/MBtu. The majority of coal produced in Eastern Kentucky is low sulfur coal, and some production complies with new source performance standards.

Referencing the Federal Energy Information Administration (*EIA*) statistics and the Annual Energy Outlook for 2006, production from the Central Appalachian coal production area, which includes eastern Kentucky, is anticipated to increase again in 2006. Factors impacting this increase are a flat electrical demand due to moderate weather conditions east of the Mississippi River, continued depletion of the existing reserve base, an increase in the shift to coal produced in the Western states (primarily production from the Powder River Basin (*PRB*) in Wyoming), imports from South America, and competitive pressures on operating costs. In Kentucky in 2006, supply shifts will probably continue to occur from coal shipped into the Commonwealth not only from the PRB, but also from the western slope of Colorado.

Increased coal production occurs when cooler temperatures exist during the winter months increasing electric generation for heating, as do hotter temperatures during the summer months due to higher air conditioning loads. Another factor is the rebuilding of utility stockpiles, which were below normal last fall because of high spot prices last summer. In early 2005, demand for Appalachian and Eastern Kentucky coal increased, and as the number of operating coal mines had contracted in prior years, spot coal prices rose and utilities deferred building stockpiles in the anticipation of lower prices and a mild winter. Currently, spot prices are at levels not previously seen since the Arab Oil Embargo of the early 1970s. The opportunity for Eastern Kentucky to continue to contribute production in the foreseeable future is great.

1.3 *Development and History of Mine Safety*

Mine health and safety during the last century was one of sustained attack and major successes. Coal fatalities have dropped from 3,000 miners per year in 1900, to fewer than 40 fatalities per year in recent years, even though coal production during the same period rose by a factor of five. Similar improvements are obvious in the metal and nonmetallic mining industry.

During the first decade of the century, mine fires and explosions were common in the coal industry, with an average of a dozen major coal mine explosions occurring each year. In 1910, Congress created the U.S. Bureau of Mines (*USBM*) to work on solving problems associated with the explosibility of coal mine dusts, developing permissible explosives, designing safer electrical systems, and developing mine rescue apparatus. The practice of rock dusting in coal mines was also initiated at about this time. In the first few decades of the USBM's history, several of the primary causes of mine explosions had been (technologically) overcome, though realization of the full benefit of these advances was not instantaneous.

By the late 1930s, a budding social revolution in the U.S. brought about more concern for industrial health and safety. Silicosis occurrences associated with a West Virginia tunneling project prompted legislation to control occupational diseases. The United Mine Workers of America (*UMWA*) became a force in the American labor movement and in seeking better conditions for coal miners. During the 1940s, great improvements were made in the fatality rates. The safety programs associated with the coal companies, particularly those captive to the steel industry, created greater emphasis on safety.

In 1952, the Federal Coal Mine Safety Act was passed, due to the continued concern for coal mine safety. The act introduced practices that had a long-term effect. The most important of these included:

- The elimination of black powder
- The adoption of systematic roof control plans
- The installation of main ventilation fans
- The elimination of underground smoking and open flame lamps
- The required use of rock dusting
- The use of water sprays for dust reduction
- The mandatory use of pre-shift examinations for mine gases in all coal mines

During the 1950s and 1960s, the number of fatalities continued to decrease, although the fatality incidence rate (number per man-hours of exposure) remained relatively unchanged. The main reason for these trends was the drop in coal production during the 1950s. Mine mechanization was another likely cause. The mechanization reduced the number of miners needed, while introducing some new hazards not previously present in the workplace. The USBM's activities in training and demonstrations, and in inspection of coal mines, also benefited safety and health.

The Federal Coal Mine Health and Safety Act (*Coal Mine Act*) of 1969 was the most significant event that affected the health and safety of miners in the last four decades. The major success of the 1969 Coal Mine Act was methane concentration control, dust control, intrinsic electrical safety and explosion-proof enclosures, minimum air quantity and quality standards, and escapeway provisions. These requirements affected mine planning, particularly mine ventilation planning, engineering, and mining practice.

The fuel crisis of the early 1970s highlighted a need for increased coal production and the shortage of trained workers. Two documents have had a far reaching effect on miner training.

- The 1974 contract between the UMWA and the Bituminous Coal Operators Association outlined health and safety training and retraining programs for all unionized bituminous coal mines.
- The 1977 Federal Mine Safety and Health Amendments Act mandated training and required that several of the training programs be conducted by instructors certified by the **U.S. Mine Safety and Health Administration *(MSHA*)**.

MSHA began offering a variety of training products and services to the mining industry. Among these were films and videotapes, instructional programs, mine emergency simulation exercises, pre-shift inspection programs, self-study books on health and safety problems, safety manuals, and other important health and safety reference documents. Finally, the introduction of remote control and automation technology in the 1980s began changing the working environment and job functions in the mines.

Since the 1980s, the number of work places/occupations placed under reduced standards has increased. There are questions on the methods of dust sampling and of determining noncompliance. There are several other health issues that need resolution. These include the high concentration of silica in airborne dust, the adequacy of sampling for exposure measurement, the need for broader view of dust related occupational lung diseases, and the unconventional work schedules. During 2005, there were only 22 fatalities in the coal industry; however, the majority of these were due to falls of roof or ribs in underground mines.

Factors currently influencing underground safety include:

- The growth in various roof support technology in underground coal mines has reduced worker exposure to hazardous conditions.
- Coalbed methane degasification as a partial solution to methane problems in highly gassy mines.
- The extensive use of remote control in the mining industry has reduced worker exposure to hazardous conditions.
- Exposure to silica in drilling operations may be eliminated or reduced by isolating the operator from the dust.
- The rapid growth of information technology, communications, and computer monitoring also enhances the safety and health environment.
- Enhanced communication will enable equipment, personnel, and environmental data and information collection on a real-time basis for controlling emergency as well as routine health and safety issues.

Computer-oriented training technology is another area of integration of information technology and communication as it will affect the way the mining industry achieves higher levels of safety.

Today there is a greater emphasis on occupational safety and health training to increase hazard awareness, knowledge of safe work practices, and safe behavior. While mandated training requirements and training curriculum are a part of today's mining regulations, this training can become mundane and repetitive. This is because health and safety functions are intertwined with other training programs that stress the interrelationships between equipment, humans, and the work environment. In general, site-specific issues; engineering and physical hazard-control systems; routine and emergency situations; have become worker and supervisory responsibilities.

Training outcomes are a function of program content, class size, manner of instruction, frequency of training, effectiveness of feedback, and instructor credentials. This makes it difficult to assess the effectiveness of a specific training program to a specific group. Computer-based training uses the capabilities of modern computers to develop, offer, evaluate, and modify training programs to overcome several of the limitations of traditional classroom and on-the-job miner training programs. Computers promote lesson design, interactivity, lesson quality, and self-based learning.

1.4 *Purpose and Qualifications*

Historically, Kentucky and other coal producing states in Appalachia have been dependent on the mining, preparation, and transport of coal as a basis of economic activity. In recent years, the dependence of states, such as Kentucky, on coal has decreased due to noteworthy local, State, and Federal efforts to diversify local economies within each state. Nonetheless, the sustained production of coal is still of tremendous importance to the local, the county, and the state economies, to the commercial strength of the Appalachian Region, and to the energy independence of the entire U.S. However, despite a sustained national level of coal production, local, county, and state economies are subject to wide fluctuations. Changing conditions in the markets in which coal is bought and sold, combined with increased concerns regarding environmental effects, may lead to significant reductions in the quantity of coal produced in some counties and states. These reductions in coal production will, in turn, have pronounced predictable impacts on the economies of coal-producing counties.

Retreat mining plays an important role in the production of coal within Kentucky and in the Appalachian Basin. Recent fatalities in the coal industry have focused attention on retreat mining practices and underground coal mining in general. The 34 Kentucky mines reviewed as part of this report produce approximately 16.7 million tons of coal per year and represent one third of all the Kentucky mines with approved retreat mining plans. Kentucky produces approximately 116.5 million tons of coal per year of which 52 million is by underground mining methods in the Eastern Kentucky coal fields. Production from mines using retreat mining practices may represent as much as 50 percent of all Eastern Kentucky underground coal production and 14 percent of all coal production in Kentucky.

Part 2. Description of Current Retreat Mining Methods

Retreat mining methods vary greatly in the Appalachian coal industry. The method used by a particular mine is selected and modified based upon local mining conditions, the availability of mining equipment, the pillar size, the success of similar methods in adjacent mines, and the opinions of mine engineers as well as State and Federal roof control specialists. Pillar extraction processes widely practiced in the industry include "Christmas Tree", "Outside Lift", "Split and Fender", "Pocket and Wing", or combinations of the methods. This section describes the methods used in Kentucky and elsewhere, and highlights the major factors to be considered in selecting each method.

2.1 *Pillar Recovery Methods*

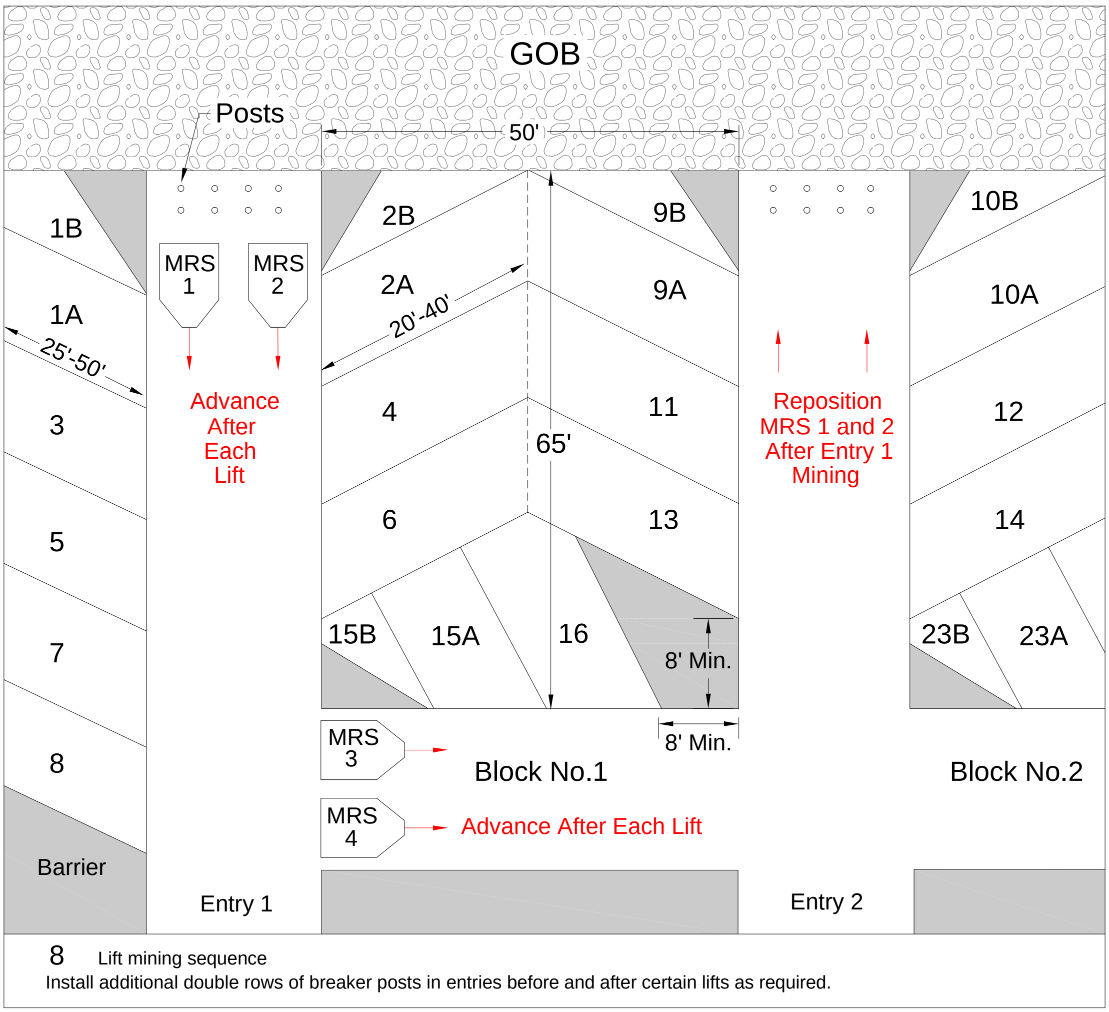
The following discussions are intended to provide a brief summary of applicable processes, for the above mentioned retreat mining (pillar removal) plans.

(a.) Christmas Tree

Today, the Christmas Tree method (also called "left-right" or "twinning") is the most commonly used pillar recovery method in the Kentucky coal industry. In this process, cuts are taken both left and right on both sides of the entry. A continuous miner removes most of the coal on each side of the entry until a chevron type pillar remains. Some plans call for splitting the chevron pillar from the crosscut. Typically, a corner wedge shaped pillar is left. In some cases, the pillar is removed by mining the stump or "pushout" from the intersection.

This method is generally employed under deep cover when pillars on 60-foot or 80-foot centers are required to maintain necessary pillar stability factors. However, it is possible to extract pillars up to 30 to 35 feet wide, but only in areas of shallow overburden and easily breakable top. The following figure depicts a common sequence in which lifts are extracted during barrier and production pillar extraction using mobile roof support (*MRS*).

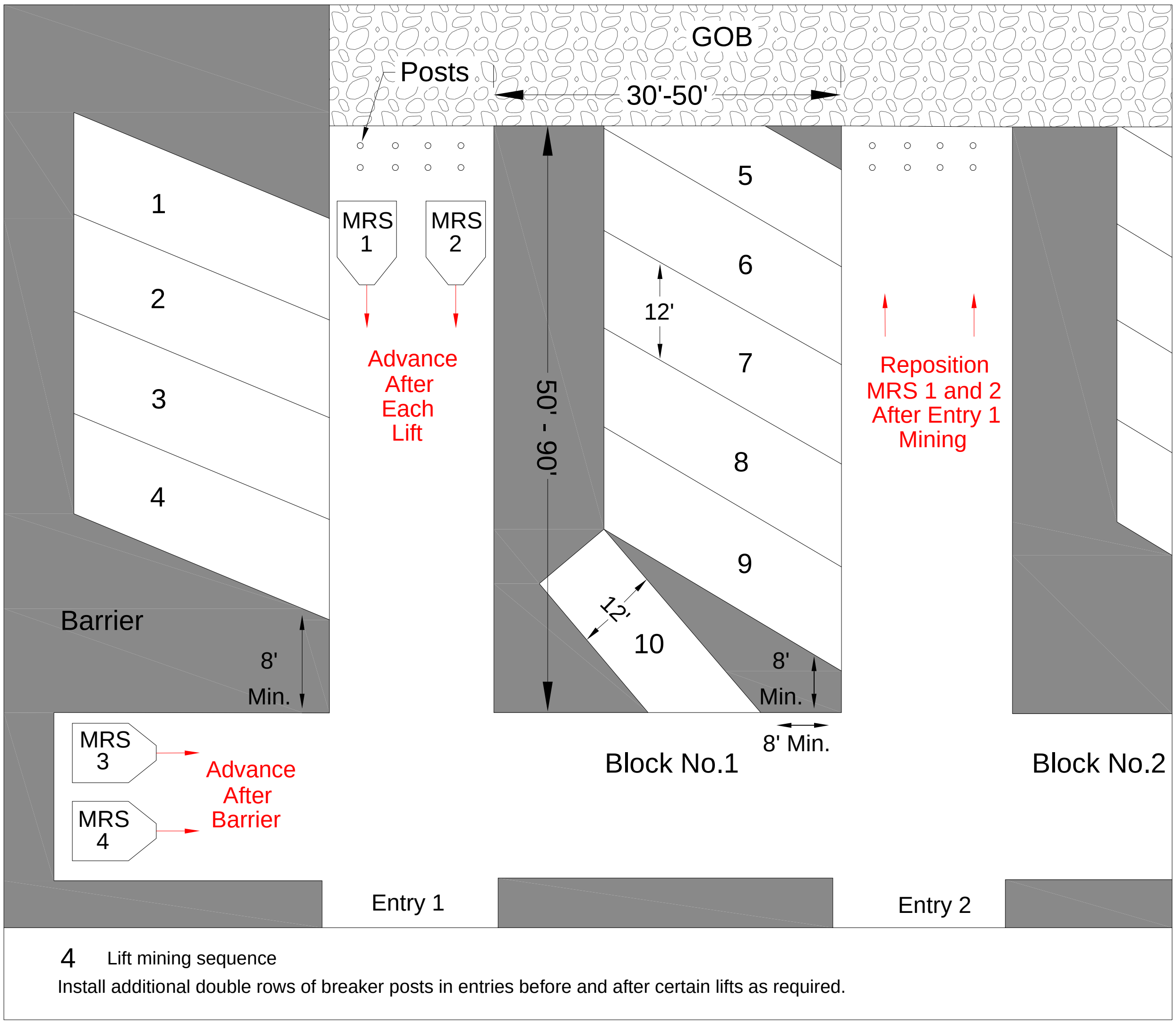
As shown in the figure, prior to mining lift 1, MRS units (1 and 2) are in Entry 1 and MRS units (3 and 4) are in the crosscut. The MRS units are pressurized against the roof and provide active support. As each lift is extracted, MRS units 1 and 2 are alternately depressurized, advanced, and re-pressurized, as close as possible to the active mining, thereby providing immediate hydraulic support in the mining area. This process continues until all of the lifts left and right, numbered 1 through 8 are mined in Entry 1. After maneuvering the continuous miner to the next entry and relocating the MRS 1 and 2 units in front of the posts, another retreat mining cycle starts in Entry 2 with lift 9.



Christmas Tree Cutting Sequence

(b.) **Outside Lift**

The Outside Lift pillar extraction process is the original process developed for the application of MRS. This method is suitable for narrow pillars when combined with extended cut mining. The variations are many, depending upon conditions, pillar dimensions, and coal haulage equipment. Generally, the pillar is sized so that lifts taken from one side of the pillar are sufficient to extract the pillar without going beyond supported roof. The sequence of cuts involves taking lifts from the pillar beginning near the gob and moving toward solid coal. The sequence of cuts shown in the following figure is typical, and the MRS units are moved in a manner similar to that previously described.

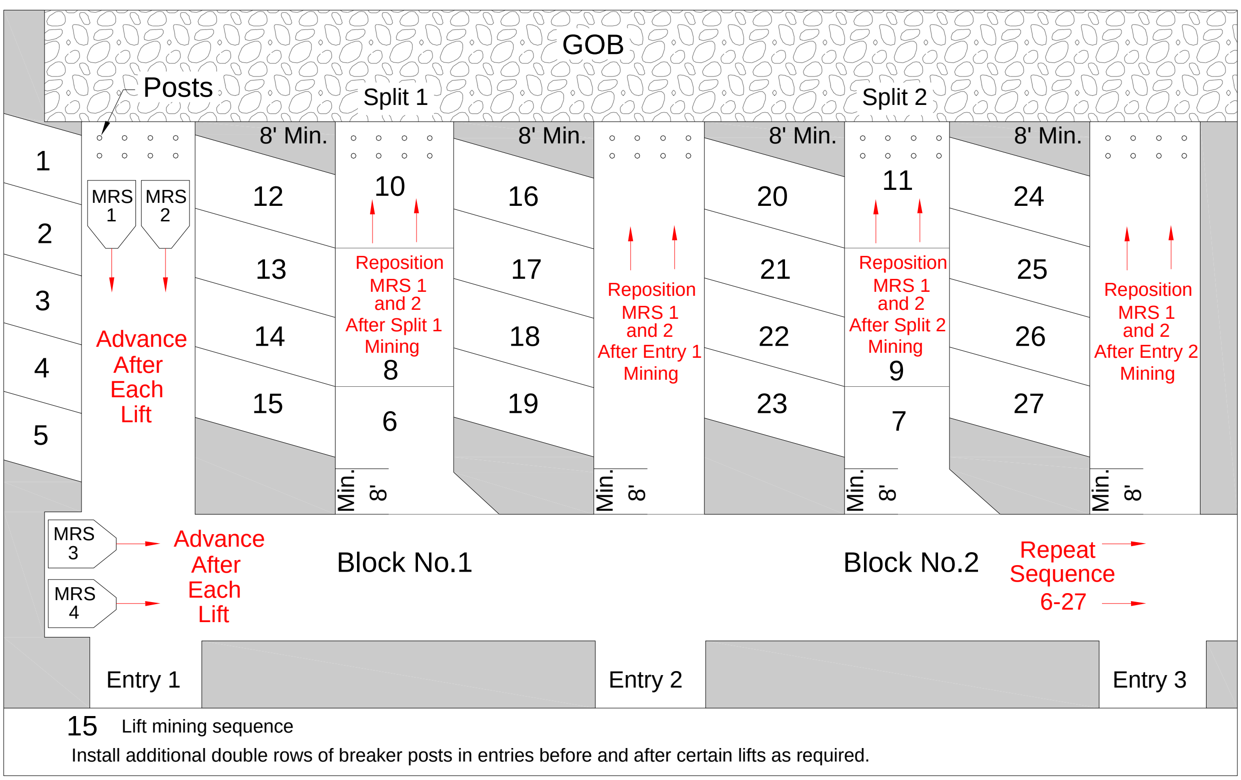


Outside Lift Method using Partial Pillar Recovery and Mobile Roof Supports

The method is generally used with an entry spacing of approximately 50 feet with crosscuts on 80 to 120-foot centers. The Outside Lift method provides added protection to the continuous miner operator because personnel are always adjacent to a solid coal pillar. One disadvantage to the Outside Lift method compared with the Christmas Tree method is that the lift lengths are usually longer (deeper). Prolonged exposure while mining deeper lifts subjects the continuous miner operator to greater risk.

(c.) Split and Fender

In 1981, the Split and Fender method was the most commonly used pillar extraction process in the U.S. It was used where a relatively small pillar was to be extracted; however, a large pillar can be extracted using multiple splits. The basic concept of the process is to mine through the pillar (split) with sequential cuts, generally parallel to the pillar's long side. This mining forms a split through the pillar and creates two fenders of coal. The roof within the split is supported by roof bolts. The fenders are extracted from the split or adjacent entry with supplemental support, generally provided by posts or MRS units. Usually, multiple pillars are extracted simultaneously in order to provide an adequate number of working places to avoid production delays.



Split and Fender Cutting Sequence, Right to Left, with Mobile Roof Supports

A typical sequence of cuts is shown in the figure above. The numbered areas in the two pillars represent the cut sequence. The sequence shown is for continuous mining equipment.

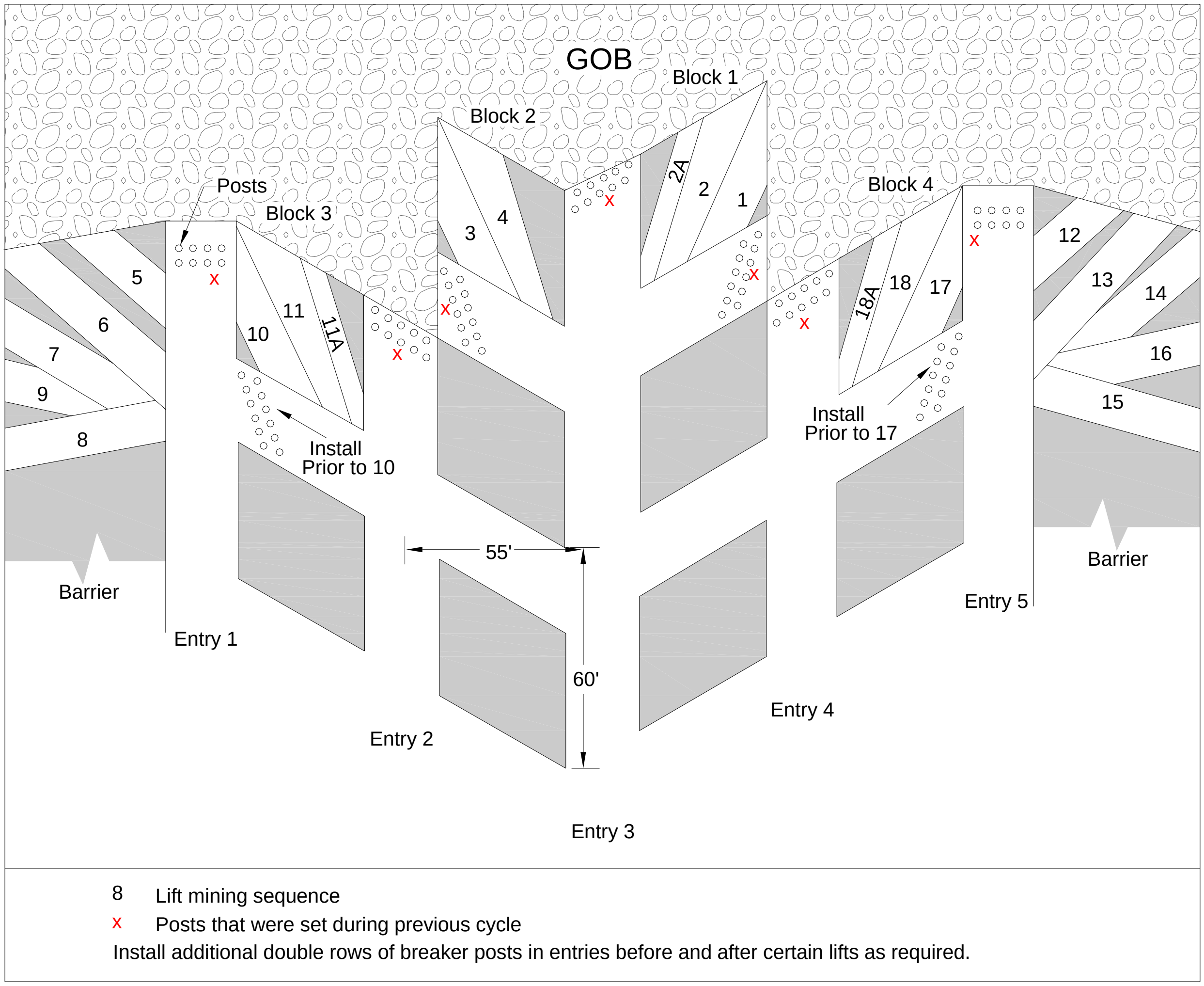
Variations are required for continuous haulage and conventional mining equipment. Again, supplemental support in the form of MRS units is shown during the retreat mining process.

(d.) <u>Pocket and Wing</u>

Pocket and Wing is a process used primarily for the extraction of large pillars and is a modification of the Split and Fender method. It is applicable under widely varying conditions, but few mining companies use it due to its many limitations. The Pocket and Wing process allows two working places within the same pillar. Pockets are driven on the gob sides of the pillar, and lifts are usually sequenced between pockets to provide a place for both mining and roof bolting. A wing, or fender, of coal is left between the pocket and the gob. When the pocket is completed, the wing is removed with sequential lifts. Additional pockets are driven and wings extracted until the pillar is reduced to a final stump or "pushout." This stump is recovered from the intersection. Additional cuts are sometimes required in adjacent pillars to eliminate production delays. It is not shown here because it is not currently used in Kentucky.

(e.) <u>Combination of Christmas Tree and Outside Lift</u>

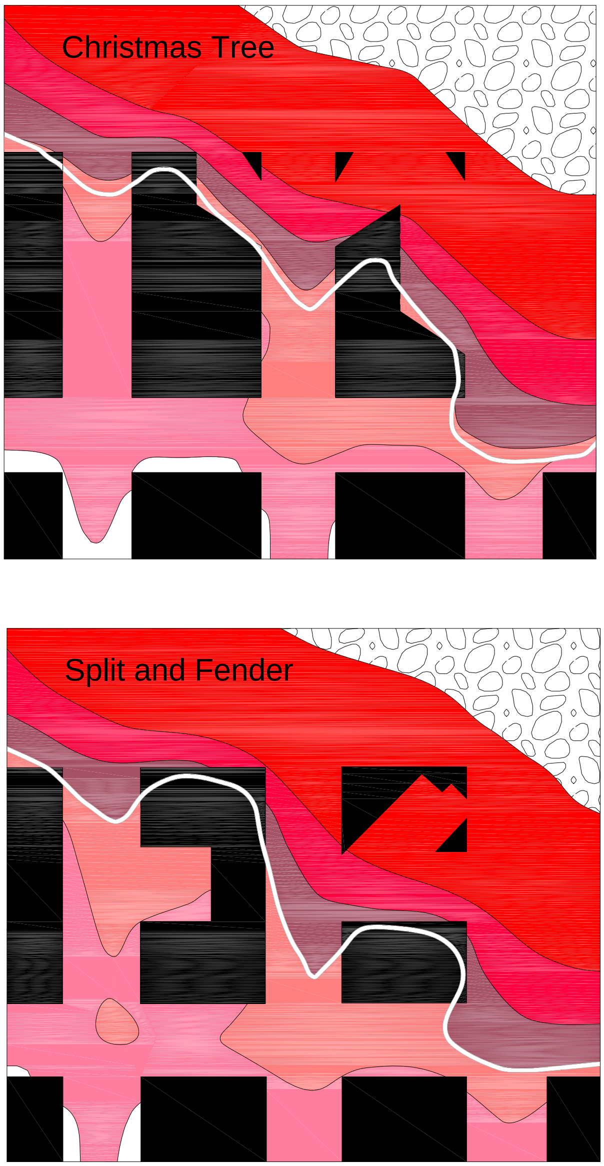
The Christmas Tree and Outside Lift methods have been used in combination for pillar systems developed with continuous haulage. When using mobile bridge conveyors, which is the most common type of continuous haulage in use, crosscuts are driven on approximately 60° angles to facilitate the movement of bridges and carriers. The parallelogram-shaped pillars (*figure below*) create a panel configuration that is usually referred to as the "herringbone" or "turkey foot" design. Common entry centers range from 50 to 60 feet, with crosscuts on 80 to 90-foot centers. Each mining cycle starts with the recovery of the two central pillars (Blocks 2 and 3) left standing out in the gob by the previous cycle. Each pillar is extracted using the Outside Lift method. After cutting lifts 1 and 2 in Block 3, the continuous miner is maneuvered to cut lifts 3 and 4 in Block 2. A variation is to cut the two central pillars using a Christmas Tree method. The extraction sequence removes the left Barrier and Block 1, then the Right Barrier and Block 4, and then the sequence repeats itself.



Combination of Christmas Tree and Outside Lift Retreat Mining with Post Supports

2.2 *Evaluation of Retreat Mining Methods*

Each of the four pillar recovery methods presented has certain advantages and disadvantages. Each is used successfully in one area or another of Kentucky, and/or the Central Appalachian Coal Basin. To provide further insight into the influence of the cut sequence on ground stability, the **National Institute of Occupational Safety and Health (*NIOSH*)** conducted a comparison of the four common pillar recovery plans in an identical mining environment (a 400-foot depth of cover and a 5-foot seam height) using a boundary element computer model (Mark, Chase, Pappas, 2003). The mining methods evaluated were the Christmas Tree, Outside Lift, Pocket and Wing, and Split and Fender. In the model, the particular pillar/opening geometries, cut sequences, and timber supports were based on actual retreat mining plans. The figure below shows predicted convergence contours (amount of roof closure during mining and confirmed by actual practice) for each of the four mining methods after roughly one-third of the coal has been mined in each pillar.



Roof Convergence Contours After Several Cuts
(The 0.1 ft convergence contour is highlighted in white)

The white line in the figure above is intended to represent an estimated amount of convergence and has been highlighted to illustrate the impact on the roof and the pillars of each mining method. The convergence data is intended to represent gross movement of the main roof/floor and higher levels would suggest an increased potential for a roof fall. The model shows the following:

- The Christmas Tree and Outside Lift methods show approximately the same convergence contour at this stage of mining.
- The Pocket and Wing and the Split and Fender methods show encroachment of the convergence contour into the entire split and extend well into the intersection outby where the lifts are being taken. This indicates yielding of the narrow coal fenders created by these methods.

In this particular analysis, the Christmas Tree and Outside Lift methods appear most likely to result in stable ground conditions. In general, the models indicate that high stress develops in the remainders or stumps of the pillars left by the mining. It illustrates that properly sized pillars withstand the stresses developed, and that undersized fenders may yield prematurely. This research has also shown that convergence, in and of itself, is not a good measure of impending roof falls. The rate of convergence is considered the primary indicator of impending roof falls. The more rapid a coal pillar or remaining fender yields under load (fails), the more rapid the differential movement of the roof, thereby triggering a roof fall.

Analyses of field data show that roof instabilities are influenced by (1) pillar failure, (2) pillar yielding, (3) mine seismicity, (4) geologic structures, (5) panel layout designs, and (6) mining practice. The actual ranking of factors depends upon the local physical and geologic parameters. In the Central Appalachian Coal Basin and under shallow cover, geologic structures may be the primary cause of roof falls, while mine seismicity, generally seen in the western U.S. is considered the lowest in priority. Geology is discussed in more detail in a subsequent section.

2.3 *Supplemental Roof Support during Retreat Mining*

Supplemental roof support is necessary in retreat mining to increase safety and minimize the risk of injury from roof falls. In current day retreat mining, there are two types of roof supports used to provide supplemental roof support while the pillar is systematically extracted: wood posts and a 4-legged mobile hydraulic support unit, MRS.

Wood posts or props were historically used in mining to provide roof support and entry stability. The advent of roof bolts has eliminated the use of wood posts as the primary means of roof support in normal room and pillar development. However, in retreat mining, wood posts are used extensively to provide supplemental support while a pillar is systematically extracted, and used in a double row to provide a barrier to roof fall extension (breaker posts). Generally, four to six posts are spaced 4 feet apart across an entry to provide support before a pillar lift is started.

The MRS is an innovation that provides supplemental and temporary roof support by hydraulic rams during pillar extraction. MRS units first appeared in the late 1980s, but have been enhanced through a series of improvements and modifications. Today's self-contained electro-hydraulic machine consists of three basic operating components: a roof support assembly, a crawler frame, and a cable reel/plow assembly. The units are always used in pairs, with two units side by side to support the mine opening, and where economically possible, four units are used to support both sides of a pillar that is being extracted.

One key advantage of MRS is that it can be operated remotely, from safer locations. Thus, the use of MRS units can be a highly effective means of reducing the risk of injury during pillar recovery, by minimizing the exposure of miners to roof falls during the placement of wood posts in retreat mining. However, the MRS units must be employed properly. These issues are discussed more extensively in the next section.

2.4 *Types of Retreat Mining Panels*

The primary method of mining coal is to drive a production panel, consisting of four to nine or more entries, 2,000 to 4,000 feet into the coal seam. The number of panels and the length of development are a function of the haulage system and the configuration of the reserve boundary. The long narrow pillar formed between parallel production panels is referred to as a barrier pillar. Any entries driven off the panel into the barrier pillar are referred to as production rooms, and the resultant pillars are called production pillars. The basic methods used by the industry include the following.

- Extraction on Retreat: The entries in the full panel are developed to its extent, and then the pillars formed during development are extracted on retreat from the farthest advance.
- Extraction on Advance and Retreat: As the panel is developed, production rooms are driven to one side, and pillars in the production rooms are extracted on advance. Once the full extent of the panel is reached, production rooms are driven to the opposite side. The pillars in both the production rooms and the panel entries are

removed upon retreat. Variations include production rooms driven to one side and extracted on retreat.

- Mains Extracted on Retreat: When the coal reserves on either set of the mains are depleted, the main entry pillars are extracted. Due to transportation and ventilation reasons, side pillars are left intact during retreat mining.

In all designs, when forming the neck off the mains or submains, several pillars are left for a sufficient distance to provide a barrier pillar. The panel is then normally widened. The width of the panel usually ranges from 300 to 600 feet and is dictated by haulage constraints or other factors. The length of the panel is usually 2,000 to 4,000 feet depending on the length of panel belt, the use of rail, or other factors.

Part 3. Evaluate Types and Effectiveness of Supplemental Support

Traditionally, timber posts provided supplemental support for pillar recovery and mining in general, as long as mining has been practiced. Each retreat mining method has different supplemental support requirements, which typically are designated as roadway, turn, and breaker posts, depending upon their location around the pillar. MRS units first appeared in the late 1980s, and became an innovation to assist in providing supplemental and temporary roof support during pillar extraction. Since that time, MRS units have been enhanced through a series of improvements and modifications. In this section, both types of supplemental roof supports are evaluated for their effectiveness and safety.

3.1 *Use of Wood Posts*

Wood posts are referred to as *conventional roof support materials* in Kentucky Administrative Regulations (*KAR*) 805 Chapter 5 Section 6. As a permanent or supplemental roof support structure, wood posts have several advantages. They are relatively lightweight, easily trimmed to desired length, and simple to install. However, from an engineering point of view, as a naturally occurring material, wood posts have several disadvantages. In addition, the installation of posts requires miners to work near the edge of the pillar line, increasing their exposure to possible unsafe roof.

First, the engineering characteristics of wood are highly unidirectional and subject to wide variation. Wood is much stronger when loaded axially (along the grain) than loaded transversely (perpendicular to the grain). State regulations require minimum sizes for wood posts as a function of mining height (805 KAR 5.6 (2)). Since soft spots, knots, and voids within the wood can cause the wooden structure to be weaker than anticipated, careful inspection of the post should be made prior to use. Yu (1987) indicated that the strength of a wood typically drops about 50 percent due to a two-inch knot. Wood generally absorbs moisture, especially in the underground coal mine environment, which decreases its engineering properties and causes unexpected low roof support capacity. As the moisture content of the wood increases, the strength of the wood generally decreases. Biron and Arioglu (1983) identified that the moisture content of wood is a major limiting factor in the strength of wood products. For pine, crushing strength decreases by 82 percent as the moisture content increases to 50 percent. This is a significant reduction in strength and will affect the performance of wood posts. Therefore, if used in high moisture environments and/or in the presence of water, a post will have limited load-bearing capacity and will not be able to provide expected support against the roof.

Second, wood posts have a limited convergence range. Wood posts can break after only 1 or 2 inches of roof-to-floor convergence and their post-failure strength is almost zero. However, wood posts generally give an audible sound when breaking, alerting nearby miners to roof convergence.

Third, setting posts requires more manpower and labor. A crew of five or more persons is required for the installation of posts because delivery, cutting to proper length, and the actual installation takes time. During the MM&A field visits, observations revealed that, in some instances, the installation of eight breaker posts after a pillar lift can take as long as 10 minutes, depending on the number of available personnel or the degree of team coordination. A lack of planning is evident when (due to debris on the floor, uneven roof, or floor undulations) the roof-to-floor clearance was not accurately measured, and the pre-cut posts were either too long or too short, requiring additional time to either re-cut the post or chisel the floor to make the post fit. MM&A believes poor post installation quality prolongs the timber setting time and exposes miners to potential roof hazards. Also, at seam heights above 7 feet, the weight and bulk of the wood posts can result in material handling injuries.

For all of these above reasons, the use of MRS units should be encouraged in seam heights above 48 inches.

3.2 *Mobile Roof Supports*

MRS technology was pioneered by the USBM[1] during the 1980s (Thompson and Frederick 1986). In 1988, the Donaldson Mine in Kanawha County, West Virginia, was the first U.S. operation to use MRS units. Currently, mines in five states utilize MRS units, including

[1] In September 1995, Congress voted to close the USBM.

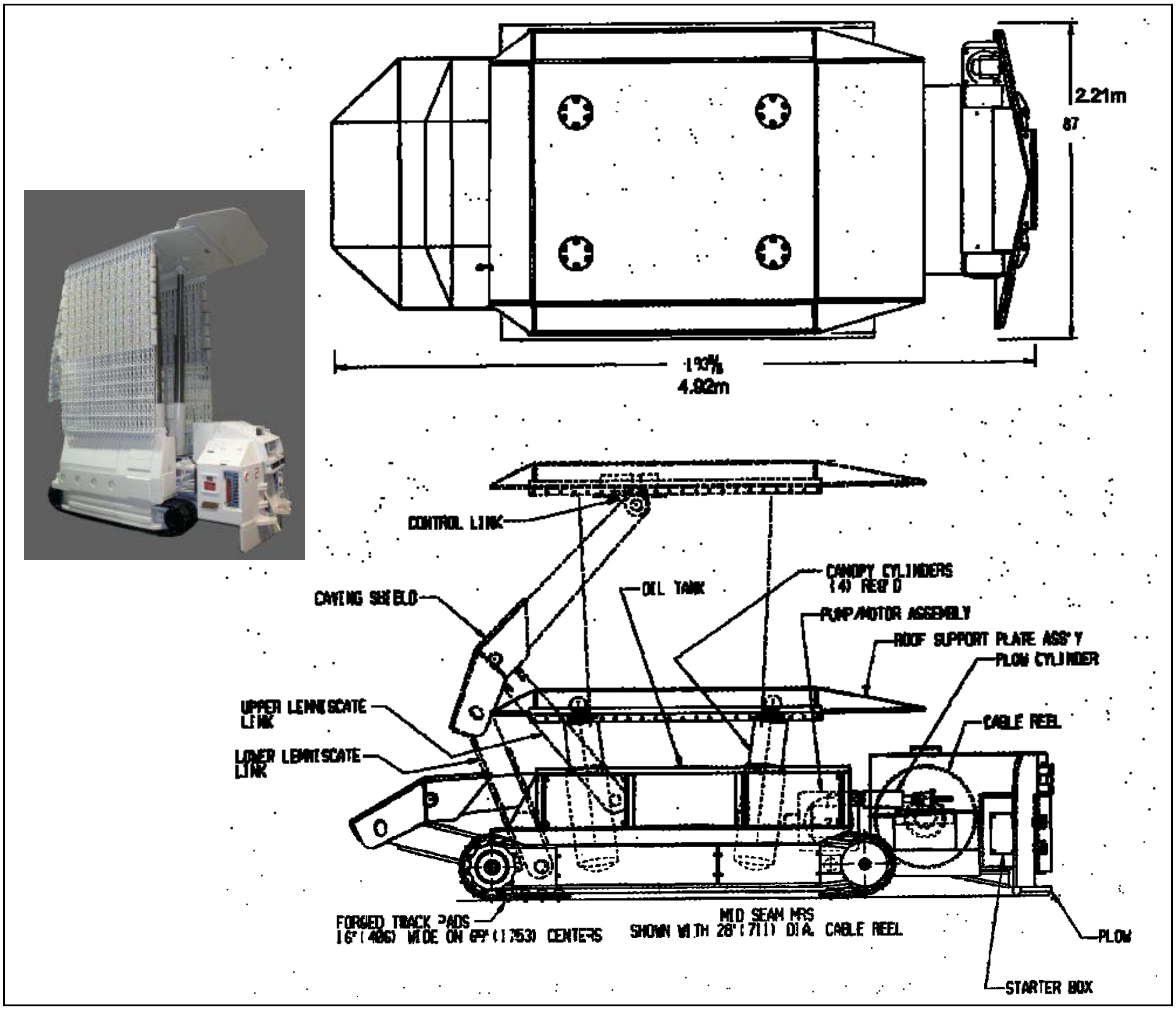
Illinois, Kentucky, Pennsylvania, Virginia, and West Virginia. MRS units are employed in more than 15 different U.S. coalbeds ranging from 5 feet to 13 feet in height. Nineteen pairs of MRS units are utilized at 10 of the 34 mines involved in the study.

(a.) Manufacturers

MRS units currently in use were developed and manufactured by a U.S. company and an Austrian company, each from a very similar concept, but with different design approaches. The two manufacturers are **J. H. Fletcher & Co. (*Fletcher*)** of Huntington, West Virginia, and **Voest-Alpine Mining and Tunneling (*Voest-Alpine*)**, of Pittsburgh, Pennsylvania, a subsidiary of **Voest-Alpine AG**, of Austria. Fletcher refers to its units as "Fletcher Mobile Roof Supports" (*FMRS*), and Voest-Alpine has designated its units as "Alpine Breaker Line Supports" (*ABLS*). Today, Fletcher is the primary supplier of MRS units.

(b.) Design

The MRS consists of three basic operating components: a roof support assembly, a crawler frame, and a cable reel/plow assembly. The MRS is a self-contained operating unit, with only an electric power cable extending to the machine. In addition, it is equipped with radio remote control so that it can be operated at a safe distance from the unit and from a position of relative safety from the danger of a roof fall (up to 300 feet away). The roof support assembly consists of a roof support plate (constructed of T-1 high strength alloy steel), four hydraulic cylinders (with a typical load capability of either 600 or 800 tons), and a caving shield with a lemniscate system (for more uniform load distribution). The unit is approximately 7 feet wide and 10 feet in length, which provides a significant roof support capability. The front and rear hydraulic cylinders act in pairs and have controllable setting pressures. The manufacturers recommend a setting pressure between 1,500 and 2,500 pounds per square inch (*psi*), although the pump is capable of generating up to 3,800 psi pressure. The cylinders have yield pressure valves so that they can maintain load to approximately 4,800 psi. Side and plan views are shown in the following figure.



MRS Structure (Fletcher 2005)

MRS units are equipped with three means of operation: manual, pendant (umbilical cord) remote control, and radio remote control. It is strongly emphasized in Fletcher's literature that these controls be used appropriately. Manual controls are for maintenance use only, and it is recommended that they never be used to tram the units. Pendant controls should only be used to tram the units outby the active pillar line. Radio remote control is designed to control all functions of the MRS unit, but especially to tram, pressurize, and depressurize the units inby the active pillar line.

For several years, Fletcher has offered an electronic option to monitor the rate of roof load that is being withstood by the four hydraulic cylinders. Research has shown that a more reliable measure of roof stability is the rate of convergence between the roof and the floor in an underground mine opening. Total convergence by itself is not a suitable indicator of roof instability. Monitoring the rate of load on MRS legs also has been found, under most circumstances, to provide warnings about major roof fall events, including failures of small pillars and narrow coal pillars (fenders) that occur during retreat mining. Pressure changes in the hydraulic cylinders are converted to loading rates that activate different colored lights on the monitoring rate unit. As the loading rate increases on the MRS, a green light indicates that there is minimal change in load rate on the MRS, a yellow light indicates that the load rate is increasing, and that additional caution is recommended. A red light indicates a rapid load rate increase and that a roof fall may occur soon. A continuously flashing red light and/or strobe light feature indicates the hydraulic cylinder load is approaching the yield of the MRS, and the unit may soon collapse. With this type of warning system, active pillar removal can be rapidly stopped and both men and equipment removed to prevent loss of life, equipment, and/or injury.

(c.) <u>Theory of MRS Units Roof Support</u>

The mechanics of load transfer from pairs of MRS units to mine strata were analyzed (Maleki, Owens, Endicott, 2001) using laboratory results, boundary-element modeling, and analytical solutions. The results showed that MRS units support roof rocks near the machines. MRS units are considerably less stiff than coal-measure rocks and therefore do not control overall roof to floor convergence. In comparison to posts, however, an MRS is capable of maintaining the yield load after significant amounts of roof-floor deformation. When used in pairs, the MRS units create a pressure arch in the roof and are able to provide an additional measure of safety, especially when extracting the pushout portion of a pillar. MRS units accelerate the mining cycle because the time required to set posts is eliminated. This reduces the potential for exposure to time-dependent roof falls (Maleki, Owens 2001).

(d.) <u>Selection</u>

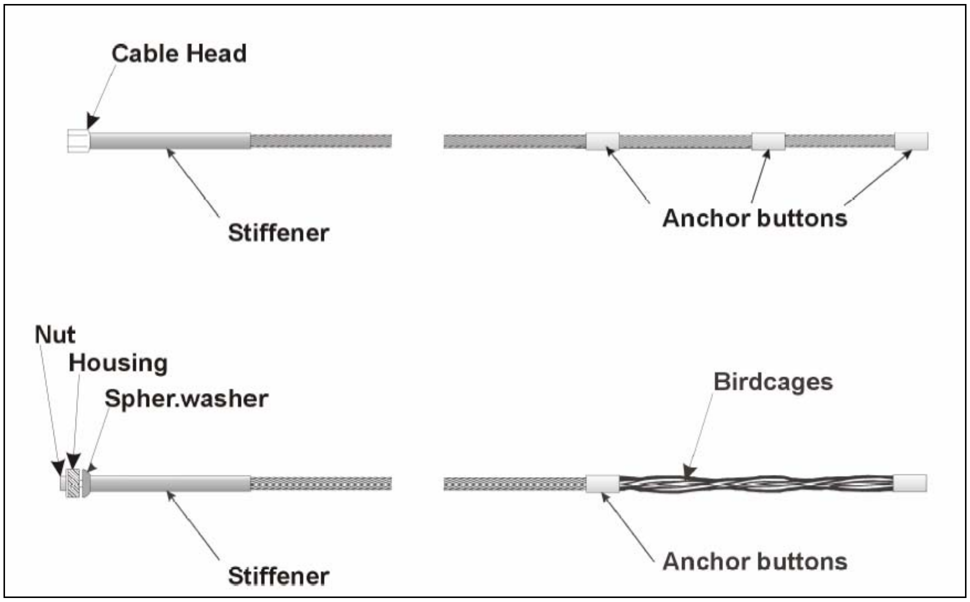
One disadvantage of the MRS units is that their operating range is limited to seams thicker than approximately 42 inches. In Eastern Kentucky, the 10 mines that use MRS units for supplemental support are operating in seams thicker than 48 inches. However, only four mines report seam conditions consistently near 4 feet, while the other mines report seam thicknesses as much as 12.5 feet. In thin seams (less than 42 inches), and other mines that do not employ MRS units, a timber plan that requires an adequate number of posts, installed at the proper times and in the proper locations, is essential. Twenty-four mines in the study use timber posts for supplemental support, and only five report seam thicknesses grater than 4 feet.

While MRS can be a highly effective means of reducing the risk of pillar recovery, it must be employed properly. One key advantage of MRS is that it can be operated remotely, from safer locations. *Mobile Roof Support Operator's Guidelines* for use of MRS supports is provided in the *Appendix*.

3.3 *Cable Bolts*

Cable bolting technology was introduced into the U.S. coal industry in the early 1990s; today these cable systems provide supplemental and secondary roof support. Cable bolts are made from a high-strength steel cable. The most common cable used to construct a cable bolt is seven strands 0.6 to 0.625 in (1.52 to 1.59 cm) in diameter. The cable consists of six outer strands wrapped around a middle or king wire strand. The cross-sectional area of the steel for the cable is 0.217 in^2 ($0.55 cm^2$). Cable bolts can be of any length, but typically range from 8 to 20 ft (2.4 to 6.1 m) for use in coal mines. The cable bolts are anchored in the roof with resin grout cartridges using only a partial grout column. This leaves a free cable length in the lower portion of the hole. Cable diameters range from 0.5 to 0.9 in (1.27 to 2.29 cm).

A cable bolt consists of a cable head that ties the cable strands together and allows the bolt to be installed and rotated with a roof bolter. For ground control, the head is necessary for the ungrouted portion of the cable to take load and resist rock movement with the installation of bearing plates and other surface control devices. A stiffener is necessary to install the cable bolt and insert it through the resin cartridge with a roof bolter. Without the stiffener, the cable is too flexible to be pushed through the resin cartridge and will bend outside the hole. Newer designs allow the cables to be tensioned at the head of the bolt. Cables with yieldable heads are available where large roof deformation is expected, and where roof loads will exceed cable strength.



(NIOSH, 2000)

Some advantages of cable bolts compared to traditional roof supports used in coal mines are detailed below.

- Wide secondary/supplemental support applications – Currently, most mines utilizing cable bolts use them in secondary and supplemental support applications. Cable bolts because of their flexibility and extended lengths have a wider range of roof support capability than traditional roof bolts, and can be installed very quickly and easily in limited seam height.
- High load capacity – A typical 7 strand cable bolt will typically yield at about 28 tons and not fail until about 32 tons. This is almost double the strength of common roof bolts and almost 3.5 times the strength of a 4 inch diameter wood post.
- Wide load/deformation range capability – Cable bolts have more deformation (or stretch) than traditional roof bolts. Common cable bolts and grout length 12 ft (3.66 m) cable will be at "yield" at about ¾ in (1.9 cm) of deformation, yet will continue to slightly build load and deform to 3 to 4 in (7.6 to 10.16 cm) of deformation.
- Lower labor/material costs – The cost and scarcity of timber have been the driving force in the development and use of new secondary support system technologies. Foremost among these technologies is cable bolting, which has replaced wood cribs as the main tailgate support in several western mines. With the application of cable bolting, a 40 percent reduction in direct labor and material costs can be achieved over that of timber cribs.
- Prevention of injuries – Originally, a reason for conducting health and safety research on cable bolts was the large number of injuries that occur from the handling of timbers and cribs. Cable bolts greatly reduce installation injuries and reduce the amount of material handling injuries when compared to using timber cribs. This frees up equipment and also reduces road traffic and maintenance.

3.4 *Evaluation of MRS, Wood Posts, and Cable Bolts*

MRS units can act as supplemental support only under certain circumstances and in certain areas. Restrictions on seam height limit MRS unit application in Eastern Kentucky where there is a predominance of thin seams. However, in mines with mining heights greater than 48 inches, MRS units are superior to wood posts for pillar extraction for several reasons. MRS units allow miners to remain further outby the pillar line, thereby reducing their exposure to roof falls from gob overrides and rib spalling. MRS units eliminate the installation of wood posts in roadway, turn, and crosscut areas during pillar recovery operations. MRS units are active supports (whereas wood posts are strictly passive), thereby providing better roof coverage and support, and are much better suited to handle eccentric load conditions (i.e., horizontal and lateral loading), which may occur during pillar extraction.

At every operation visited by MM&A, mine personnel expressed the opinion that MRS usage enhances pillar line stability and safety. Yet, in three accidents in the last three years (not all in Kentucky) on MRS sections, miners have been killed standing in the active intersection as the last lift was being mined or after it was completed. A more detailed discussion on this topic is covered under *Part 8* of the report.

Cable bolts provide enhanced support capability especially where the thickness of the roof beam needs to be increased to provide additional support of overlying rock during certain portions of the retreat mining cycle where greater convergence is anticipated, and where suspension of weak strata is necessary from stronger overlying rock strata. The cost of cable bolts is however, significantly greater than wood posts, and only in thick seams or in mines where additional supplemental support is needed due to geological conditions should their application be considered.

Part 4. Roof Stability Conditions

As roof stability is the major consideration in preventing roof falls, MM&A categorized all the factors that may affect roof stability at the active retreat mining section into the following subjects.

- Geology
- Over/under Seam Mining
- Global Pillar Stability, as defined below, which include proper pillar design and panel pillar design
- Local Stability Factors, which affect the stability of the active intersection just outby the pillar being extracted; they include the roof geology, the size of final stump, the effectiveness of supplemental roof supports, and the type of primary support (roof bolt design and pattern)
- Lineaments from satellite imagery
- Other factors, including multi-seam mining effect, large scale geologic features, lineaments, deep mining (greater than 650 feet), use of continuous haulage, age of workings, etc.

4.1 *Geology and Roof Stability*

The geology of the overlying rocks considers the type of rock or strata (sandstone, shale, claystone, fireclay, etc.), the number of times it changes from one rock type to another, and the thickness of each rock type. It also considers the strength of each rock type; the frequency, orientation, and condition of discontinuities, faults, or bedding planes in the rock; and ground water inflow. The intent and purpose of roof bolting is to assist the rock in becoming self supporting. It binds the various rock layers together into a beam, which bridges the mine openings, or it suspends weak strata from a stronger overlying strata. In general, the wider the mine opening, the thicker the beam that is required, and the longer the roof bolts. Roof stability therefore relies upon an understanding of the roof geology and how well roof bolts and other supplemental supports are adapted to that geology.

During retreat mining, the pillars are removed allowing the overlying roof rocks to cave, generally in a predictable manner. The caving action is well defined and predicated upon the same characteristics. Rock failures or roof falls which do not occur in a predicted manner typically occur along pre-existing planes of weakness or fractures in the rock, such as bedding planes, slickensides, through plant fossils, or coal spars (thin coal layers in between the rock layers.). Upon pillar removal, the overlying roof rock cantilevers over the extracted opening, until its overhanging weight exceeds its tensile strength, and it caves. Well reinforced and stable roof only caves in the predictable manner. The key factor in improving safety is successfully maintaining roof stability before, during, and after retreat mining. Each retreat mining method and type of supplemental support has distinct advantages and disadvantages in maintaining roof stability. Understanding the impact of each method, depend upon the definition of the roof geology.

Drilling boreholes into the ground and analyzing the core obtained from the borehole provides a detailed geologic record and is used to define the roof rock mass. This information is generally obtained by coal companies during the exploration of coal. Also, some of this information is given to the **Kentucky Geological Survey (*KGS*),** which maintains a database of the borehole information. Therefore, the description of the roof rocks can only be obtained from company records or from the public database. For the 34 mines defined in this study, MM&A computer searched the public database by inputting the coordinates for each mine, and examining all boreholes within one mile of the mine. In reviewing the output data, rarely was a borehole in close enough proximity to the existing mine to have any relevance. At times, the information contained in the KGS database was inconsistent, lacked sufficient detail to be applicable, or the borehole was not drilled deep enough to provide the requisite information. Consequently, the company must provide information regarding the roof rock to demonstrate the stability of the roof during retreat mining operations. There are no public databases with sufficient information to assist the **Kentucky Office of Mine Safety and Licensing (*KYOMSL*)** in judging the geology for the applicant when filing its roof control plan.

4.2 *Proximity of Over/Under Seam Mining*

For the 34 mines in the study, the mine maps of all abandoned overlying or underlying seam mines were reviewed to determine if there was the potential for adjacent seam mining impacts, and what would be the probable nature of those impacts. The analysis showed that for 11 of the 34 mines there was neither mining above or below the active mining operation, and that the same number, 11 of the 34 mines, had been both overmined and undermined. In the remaining 12 mines, prior mining occurred at different intervals either above or below the active mine. A summary of the proximity of mines above or below the study sample is presented in *Appendix Table 2* and summarized below.

Distance Above or Below (Feet)	Number Overmined	Number Undermined
>500	1	2
<500	2	1
<400	2	1
<300	4	1
<200	6	6
<100	4	4
None	15	19

The typical impact of overlying or underlying seams is the development of stress concentrations arising from barrier pillars in the previously mined seams. Another significant impact of overlying seams is the presence of water in the abandoned mine workings. A more detailed review of the mines within 100 feet showed definite interseam impacts. Most operators either anticipated the impacts and provided for columnization of mains, submains, and production panels, or discovered a significant quantity of strong rocks (sandstone or coarse sandy shale) in the interval between the seams. A sufficient thickness of strong rock can act to minimize interseam impacts by redistributing ground stress over a wide area. Seams above 100 feet typically did not have an impact upon mining, due to either stress redistribution in the interburden or the pillared areas did not pose a risk from flooding.

4.3 *Global Stability Factor --- ARMPS Study*

Underground pillar stability is a function of coal strength, depth of cover, pillar size, mining height, panel width, barrier pillar width, and other relevant geotechnical parameters. Pillars support the weight (load) of the overlying strata, and the ability of the pillar to support the load, its pillar stability, is measured by its safety factor, the pillars strength divided by the load it carries. If the pillar load exceeds pillar strength, pillar failure may occur. There are three main types of pillar failure that can occur during mining --- pillar squeeze, massive collapses, and bumps --- and each can be mitigated by proper pillar design (Mark and Zelanko, 2005). The local stability of a pillar means it is of a size and shape to maintain the stability of the mine roof along each side of the pillar. The slow failure of a pillar generally results in roof stability problems. If a single pillar fails suddenly and completely, it is referred to as a bump. Global stability refers to the stability of a system of pillars. If a group of pillars fail, then the failure is either slow (pillar squeeze) or rapidly (massive collapse).

During retreat mining, complex mining geometries occur because of the extraction sequence and the impact of remnant pillars left in the gob. The load originally supported by the pillars being extracted is generally transferred to adjacent pillars within the active mining zone. Consequently, the adjacent pillars are not only subjected to development loads, but also abutment loads. Thus, pillar stability must be assessed for both local stability and global stability. Satisfactory global stability can be achieved by selecting proper pillar sizes, panel widths, and barrier pillar widths according to given mining conditions.

(a.) ARMPS Introduction

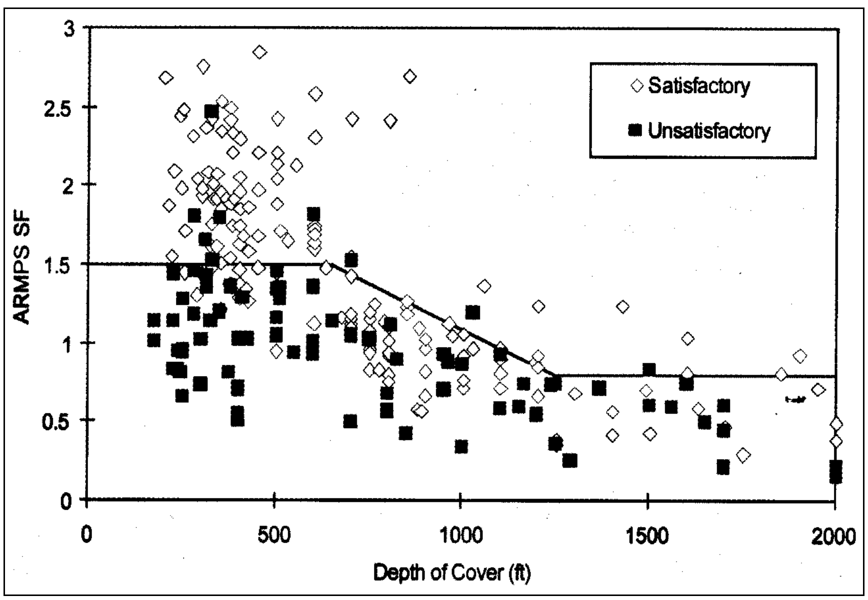
The **National Institute for Occupational Safety and Health (*NIOSH*)** Pittsburgh Research Laboratory developed the Analysis of Retreat Mining Pillar Stability (*ARMPS*)[2] computer program to aid in the design of pillar recovery operations. ARMPS can be used to calculate the safety factor of one or more pillars to help ensure that the pillars developed for future pillar recovery in retreat mining are of adequate size for all possible loading conditions, which include:

- Loading Condition 1: The pillars experience development loads only, and no retreat mining has occurred.
- Loading Condition 2: The active panel is being fully retreated, and there is no adjacent mined-out zone on either side. The total applied load is the combination of development load and front abutment load.
- Loading Condition 3: The active retreat mining zone is adjacent to a mined-out area on one side, and, thus, the pillars are subjected to development load, front abutment load, and/or side abutment load on one side.

[2] Pittsburgh, PA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Technology News 464, 1997 Jul 1-2.

- Loading Condition 4: The active mining zone is surrounded by gob on three sides; therefore, the pillars are subjected to development load, front abutment load, and/or side abutment load on both sides.

Appropriate safety factors for global stability has been established by calculating the ARMPS safety factors for actual pillar recovery case histories (Mark and Zelanko, 2005), and comparing stable conditions versus conditions that failed. It was found that, for depths less than 625 feet, pillar stability factors (*SF*) that exceed 1.5 have generally been effective (see figure below). Under deeper cover (more than 1,250 feet), the recommended minimum stability factor is 0.75. In any case, other precautions, such as proper barrier pillar size and appropriate panel spacing, are necessary. The figure below illustrates the boundary for unsatisfactory production panel pillar designs.

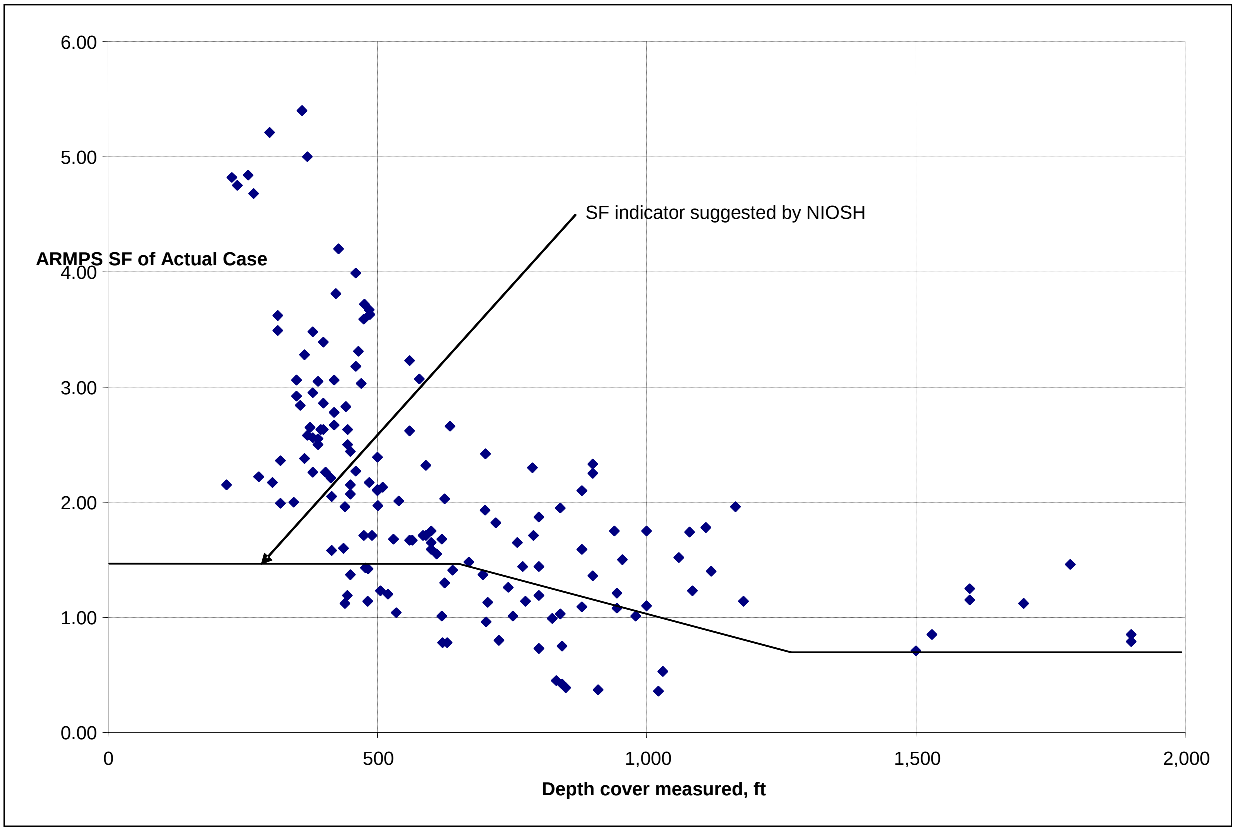


Suggested ARMPS SF based on a Case History Data Base (Mark and Zelanko, 2005)

(b.) ARMPS in this Study

In this study, for each of the 34 subject mines, after reviewing its retreat mining plans and the mine map, MM&A selected several representative locations at each mine and calculated the ARMPS stability factors. The sites selected were based on the pillar size, number of entries, depth, barrier pillar width, and loading conditions. For each location, MM&A calculated the depth, seam thickness, and other relevant parameters, and then utilized ARMPS (version 5.0) to estimate the pillar stability factors. There were 165 locations selected in total for all the 34 coal mines, and the *Appendix Table 4* lists the calculation results.

Following an approach similar to that of NIOSH (Mark and Zelanko, 2005), MM&A plotted the safety factors for 165 mine locations versus depth (see figure below).



ARMPS Stability Factor vs. Depth Cover Measured

YTD 3rd Qtr 2005	Number of Mines	Number of Roof Falls	FIR	NFDL-IR	RF Accidents*	RFA-IR	Tons
Less Than Criteria	9	27	0.000	8.33	34	4.29	4,677,303
Greater Than Criteria	25	42	0.250	4.92	39	3.25	8,727,663

It is clear that the pillar stability factors of 131 out of the 165 selected sites are above the minimum requirement suggested by NIOSH. The remaining 34 sites have pillar stability factors lower than the value recommended in the NIOSH research. A comparison of safety statistics (see summary table above) shows that the mines less than the criteria had a higher number of reportable roof falls, a higher Non-Fatal Days Lost Incident Rate (NFDL-IR), and a higher Roof Fall Accident Incident Rate (RFA-IR) YTD 3rd Quarter 2005, than those mines with ARMPS factors greater than the criteria. These facts indicate that low pillar stability factors correlate to high roof fall incidents. Of note is that the 2004 – 2005 fatalities occurred at mines with ARMPS' factors greater than the criteria. It should be observed that all the differences noted above and shown below may be due to geological conditions between the different mines, and/or to the implementation of specific type of retreat mining, rather than the method or practice of retreat mining, itself.

4.4 *Local Stability Factors*

Proper global stability design can effectively decrease the possibility of pillar squeeze, or massive collapse, which may cause serious injury in underground coal mines. However, global stability is a necessary, but not sufficient condition for ensuring a safe working area. Local stability here refers to the stability of openings within the active mining zone including the entry, crosscut, and intersection just out by the pillar being extracted.

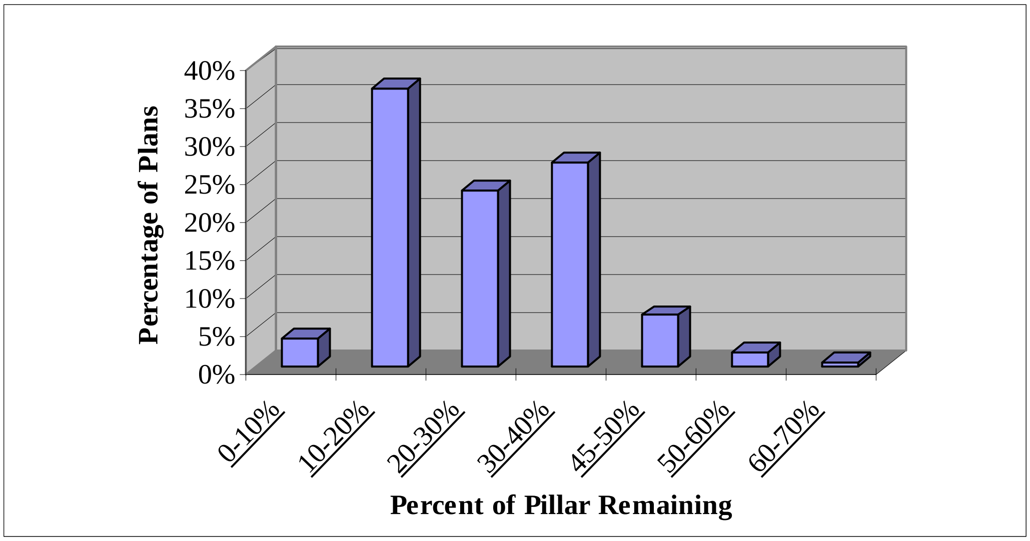
The local stability is affected by various factors including, the method of retreat mining, the geology of the immediate roof, the size of final stump, the effectiveness of supplemental roof support equipment, and the primary roof supports installed during development. The pillar recovery methods and effectiveness of supplemental roof support equipment have been discussed and evaluated in this report in **Part 2** and **Part 3**, respectively. The factors regarding removal of the final stump, and support in the intersection are discussed below.

(a.) Removal of the Final Stump and Intersection Impacts

An optimum pillar extraction plan is one that provides safe mining conditions during the extraction of the pillar, but removes as much of the pillar as possible without inhibiting the caving action. The final pushout stump is the corner of the pillar at the intersection, usually a wedge shaped area that helps protect the active intersection. The roof in the intersection is most susceptible to convergence due to removal of the pillar. Once the pushout stump is removed, or is made too small to provide adequate support, the roof in the intersection may become unstable.

The percentage of remnant pillar (ratio of remaining pillar area to the original pillar area) is the index for size of the final stump. Review of the 165 retreat mining plans submitted by the 34 subject mines shows that the remnant pillar sizing varies considerably. The following figure lists the number of plans for each range of the pillar extraction percentage. For example, 37 percent of the plans leave 10 – 20 percent of pillar as stumps in the gob.

Four plans (from two mines) are considered partial pillaring plans, which usually involve only pillar splitting or minimal slabbing and more than 50 percent of the pillar remains. One hundred twenty eight plans or 77 percent of the total contain provisions for taking the lifts from the crosscuts while 31 plans (from eight mines) or 19 percent do not take any lifts from the crosscut side. Most of the retreat mining plans specify minimum corner-to-cut distances of all the corner stumps, and the majority of the minimum corner-to-cut distance of mines in the study range from 4 feet to 12 feet, and 8 feet is the median distance.



Although well-founded theories and guidelines have not yet been developed, the preliminary guideline suggested by NIOSH can be a good starting point, as shown in the table below.

Seam Height, ft	Corner-to-cut distance, ft
4	8.5
6	9.5
8	10
12	10.5

The pushout stump closest to the active intersection is considered the most effective structure to support the roof in the intersection. A properly sized final stump reduces the risk of a hazardous premature roof fall (Mark and Zelanko, 2001). The decision to remove the final or pushout stump will have a large impact on roof stability the intersection. The decision to remove the stump should be based upon the geology of the immediate roof and whether or not supplemental roof support is required in the intersection.

4.5 *Lineaments*

One of the outcomes from high altitude (satellite) photography has been the observation of lineaments or linear features observed in photographically enhanced images. Lineament mapping and analysis have been widely used as an aid in a variety of natural resource exploration and exploitation programs. Despite the lack of consensus on lineament genesis, geologists have been using lineaments successfully as an exploration tool for a number of years. Their application is well known in the search for oil and gas (especially in the Appalachians), prediction of potentially fractured strata in coalmines, and for a variety of mineral assessments worldwide. Recently, lineament studies have been applied to exploration and production in coalbed methane.

In general, lineaments viewed on remotely sensed imagery are generally expressed as a topographic alignment that appears to be structurally controlled. These structural lineaments include obvious features such as fault scarps, fault traces, truncated structures, or anomalously straight stream courses. They are more commonly recognized by less obvious features such as a series of aligned small stream segments, linear vegetation anomalies, soil, or other tonal anomalies across cultivated fields, or a series of subtle depressions transecting an area in a linear fashion. Most lineaments do not exhibit a consistent topographic expression; instead they are identified on imagery by a combination of some or all of these criteria. The terms lineament, photolineament, and fracture trace are often used interchangeably and apply to the natural alignment of geologic, tectonic, or topographic features.

In this study, readily available mapping of lineaments in Eastern Kentucky was obtained from the KGS, and compared with the mine locations for the mines in the study. The location of the lineaments and the mines in the study are shown on *Map 1*. At several mines, the lineaments were close enough to the mines to warrant detailed examination by locating the lineament on the mine map. The results of these comparisons were inconsequential. The lineaments were either not in proximity to the mining areas to determine if there was an impact, or were previously mined and no observable impact could be seen in the mining patterns. In general, it has been the experience of the Researchers, that the mapping of lineaments and the occurrence of local geologic conditions that impact mine roof is coincidental. More often the local geologic conditions that impact mine roof are not defined by lineaments or the lineaments are found to be non-contributory on roof stability. Therefore, the researchers conclude that a no improvement in safety would occur if a requirement to review lineaments was made a part of a roof support plan or retreat mining plan.

4.6 *Other Factors Affecting Roof Stability*

When adverse roof conditions are encountered such as horsebacks, slickenedsided slip formations, clay veins, kettle bottoms, surface cracks, mud streaks, or similar type of condition in the mine roof, supplemental roof supports should be installed in addition to the primary roof support, as appropriate in the affected area.

Adverse roof conditions that need to be identified on a cut by cut basis, other than isolated instances of draw shale and evaluated by visual examinations, test holes, or other means, include:

- A constant flow of water through the mine roof
- A transitional change in the type of mine roof that results in adverse conditions (such as sandstone roof changing to shale roof)
- Evidence of horizontal stress such as cutters in the mine roof along the rib
- Draw rock not being mined with the coal
- "Drummy" or loose roof in an adjoining cut or the cut being mined
- Mining under radical changes in cover or areas where the overburden thins and results in adverse roof conditions
- Evidence of slips, rider seams, draw rock or other sub-normal conditions in the entry adjoining the active mining area
- Other detectable conditions such as excessive loading of roof bolts, unusual spalling of ribs, or heaving of floor

Part 5. Mine Site Inspections

MM&A conducted five site visits to assess the implementation of retreat mining practices compared to the procedures documented in the pillar plans submitted to the regulatory agencies. MM&A visited five mines[3] that were currently conducting retreat mining including mines in Harlan, Knott, and Pike Counties.

5.1 *Mine No. 15*

Mine No. 15 was visited on December 19, 2005, and is in the Amburgy seam in Knott County. The mine is a two-section mine operating two shifts per day, with approximately 14 personnel at the retreat mining section. The method of retreat mining utilizes two **Joy Manufacturing Co. (*Joy*)** model 14-10 continuous miners. In the retreat mining plan, the pillars are split on each side to a depth of 40 feet. Each split is 16 to 20 feet wide, removing as much as 68 percent of the pillar. The remaining stump is not mined, and consequently, the system can be referred to as pillar splitting, which limits the amount of extraction. The immediate roof in the retreat mining plan was described as 1 foot 5 inches of shale or sandstone. There is approximately 700 feet of cover.

During retreat mining, MM&A observed "roof working" and pillar spalling (portions of the side of the pillar break off in thin layers and fall to the floor). The entry width is 20 feet or less, the entry spacing is 55 feet, the crosscut spacing is 80 feet, and the crosscut angle is 90°. The pillars are approximately seven months old when mined, are nominally 35 feet by 60 feet. Operations followed the pillar plan, as submitted to regulatory authorities. Typically, the remaining pillar split was marked by the foreman, and equipment operators were careful to keep the minimum pillar stump as required. During the mining of one lift sequence, a post was unexpectedly knocked over by the continuous miner, and there was no attempt to replace the post, as it occurred toward the end of the lift and the miner was ready to retreat.

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[3] MM&A assigned identification numbers to the 34 study mines and are not the actual names of the mine.

The sequence of extraction was in a center-left-right pillaring direction. While MRS units had been used in the past, the seam is currently too low to use them. As mining progresses, one side of the pillar section has retreat mining areas on three sides. The entries are supported on 4-inch diameter posts. The timber posts are primarily constructed of poplar and oak wood. Timbers were not observed to be taking weight, as no post buckling or breaking occurred, even up to one crosscut outby the current pillar line.

Above portions of the mine, the Hazard No. 4 seam was mined at an interval of approximately 250 feet.

5.2 *Mine No. 19*

Mine No. 19 was visited on December 20, 2005, and is in the Pond Creek seam in Pike County. The mine is a three-section mine, operating two production shifts and one maintenance shift per day with approximately nine personnel at the retreat mining section. The method of retreat mining utilizes a Joy model 14-15 continuous miner and a "3-Cut Plan" with a left-center-right pillaring direction or right-center-left pillaring direction, depending on the specific area. There are no MRS units being utilized. The entries are supported on timber posts that are 6 inch round diameter or 9 inch split timbers. The retreat mining plan removes approximately 84 percent of the remaining 30 foot by 40 foot pillars, by excavating up to a 20-foot wide cut on three sides of a pillar. The immediate roof in the retreat mining plan was described as 10 feet of shale overlain by shale with sandstone streaks. MM&A found the mine to have predominantly shale roof. Some horizontal stress was noted (cutters).

During retreat mining, MM&A heard popping and cracking sounds as the weight of the overburden shifted onto the remainders of the pillar splits. MM&A observed that the roof and pillars were taking weight. Caving on the previous pillar line occurred rapidly. When the posts failed, they usually bowed in the middle and then snapped. The entry width is 20 feet or less, the entry spacing is 50 feet, the crosscut spacing is 60 feet, and the pillars, which are approximately two months old, are 30 feet by 40 feet. MM&A estimates that the depth of cover is approximately 400 feet at the observed location, which would not be considered excessive. The operator generally followed the pillar plan. However, one pillar split observed was initiated within 3 feet of the pillar corner.

The ARMPS investigation conducted by the Researchers identified that Mine No. 19 was estimated to have several plans where the ARMPS factors was less than the recommended minimum; however, the Researchers did not observe any evidence of a pillar squeeze or a massive pillar collapse. Of course, areas of maximum cover were not observed. Mine No. 19 was not overmined or undermined.

5.3 *Mine No. 25*

Mine No. 25 was visited on December 16, 2005, and is in the Elkhorn No. 1 seam in Pike County. The mine is a single-section mine operating two shifts per day with approximately nine personnel at the retreat mining section. The method of retreat mining is to remove approximately 31 percent of the remaining 50 foot by 50 foot pillars by excavating up to a 20-foot wide cut on each side of the pillar. The remaining stump is not mined, and consequently, the system can be referred to as pillar splitting, which limits the amount of extraction. The immediate roof in the retreat mining plan was described as 8 feet of sandstone overlain by another 50 feet of interbedded sandstone and shale. MM&A found the mine to have predominantly sandstone roof with about 15 percent shale or laminated sandstone. MM&A occasionally observed shale lenses in the roof, commonly referred to as horsebacks because of their shape. Horsebacks pose an unusual threat during retreat mining as they frequently separate from the main roof and fall, if not supported with supplemental roof support.

The mine was not originally planned or designed for retreat mining, and several ventilation modifications were necessary to prepare the mine for retreat mining. In addition, the operator commented that the pillar sizes were not optimum for full pillar extraction. During retreat mining, MM&A heard occasional popping and cracking sounds as the weight of the overburden shifted onto the remainders of the pillar splits. However, there was no observable collapse or movement of the pillars or the pillar ribs. MM&A estimates that the depth of cover is approximately 300 feet at the observed location, which would not be considered excessive. The operator followed the pillar plan; however, there were two practices not discussed in the pillar plan. When mining a left handed pillar split, the operator cut the inby pillar split (approximately 12 feet wide) before cutting the outby split (approximately 4-8 feet wide). This was the reverse when cutting the right handed pillar split. Typically, the pillar split was initiated within 3 feet of the pillar corner. The operator was observed moving to the middle of the entry to move the miner cable during mining the left handed cut. Due to the mining sequence, the operator was past the rib line on the left side.

The sequence of extraction was from right to left with the last pillar splits having retreat mining areas on three sides. The entries are supported on 5-inch diameter (20 square inches) posts. Timbers were not observed to be taking weight, as no post buckling or breaking occurred, even up to one crosscut outby the current pillar line. Above portions of the mine, the Elkhorn No. 2 seam was mined at intervals of 15 to 50 feet above the mine, and, in other areas, the Elkhorn No. 3 seam was mined.

The ARMPS investigation conducted by the researchers identified that Mine No. 25 had two locations where the ARMPS factors were less than the recommended minimum. These locations were in an area of the mine reported to have approximately 750 feet of cover. It was reported that management observed excessive stress conditions on the pillars and posts in this area of the mine. A review of the mine map with management identified that such cover conditions would not be encountered during the remaining life of the mine.

5.4 *Mine No. 30*

Mine No. 30 was visited on December 21, 2005, and is in the Pond Creek, also known as the Lower Elkhorn seam, near Sidney in Pike County. The mine is a three-section mine with two active pillar sections operating two production shifts and one maintenance shift per day, with approximately six - seven personnel at the retreat mining sections. The method of retreat mining utilizes a Joy model 12CM12 continuous miner and two or three shuttle cars operating in a left-center-right pillaring direction. Four MRS units, manufactured by Fletcher, are employed at the active mining section. The pressure on these MRS units is set at 2,000 pounds psi. The method of retreat mining is to remove approximately 65 to 80 percent of the remaining 50 foot by 50 foot pillars by excavating consecutive 20-foot wide cuts on each side of the pillar. The remaining stump is not mined, and consequently, a chevron shaped pillar remains. The immediate roof in the retreat mining plan was described as a shale top.

During retreat mining, MM&A observed no pillar failure and heard no popping and cracking sounds as the weight of the overburden shifted onto the remainders of the pillar splits. There was no observable collapse or movement of the pillars or the pillar ribs. The mine shaft is 210 feet deep, the mining height is 7-8 feet, the entry width was measured at 19 feet, the entry spacing is 70 feet, the crosscut spacing is 70 feet, the crosscut angle is 90°, and the pillars, which are approximately one month old, are 50 feet by 50 feet. MM&A estimates that the overburden was approximately 500 feet at the observed location.

The operator followed the pillar plan. The sequence of extraction was from left-center-right. Timbers were not observed to be taking weight as no post buckling or breaking occurred, even up to one crosscut outby the current pillar line. Above portions of the mine, an overlying seam was mined at undetermined intervals above the mine, but not in the area where MM&A was present. There were no indications of high stress conditions.

5.5 *Mine No. 34*

Mine No. 34 was visited on January 5, 2006, and is in the Darby seam in Harlan County. The mine is a two-section mine with one active pillar section operating two production shifts and one maintenance shift per day with approximately six - seven personnel at the retreat mining sections. The method of retreat mining utilizes a Joy model 12CM12 continuous miner and two or three shuttle cars operating in a left-center-right pillaring direction. Four MRS units, manufactured by Fletcher, are employed at the active mining section. The pressure on these units is set at 2,000 psi. The method of retreat mining is to remove approximately 80 to 95 percent of the remaining 75 foot by 75 foot pillars by excavating consecutive 12-foot wide cuts on each side of the pillar and in the crosscut, leaving two wedge-shaped stumps. The remaining stump is approximately 10 feet long along each side and is not mined. The immediate roof in the retreat mining plan was described as 10 feet of shale top overlain by sandstone.

During retreat mining, MM&A observed no pillar failure. Popping and cracking sounds could be heard emanating from the tops of pillar corners as the weight of the roof shifted onto the remainders of the pillar splits. Although there was some minor spalling from these pillar corners, there was no observable collapse or movement of the pillars or the pillar ribs. The mine is accessed by drift, but the overburden thickness increases rapidly with the mountainous terrain. At the location visited, the coal seam was 1,210 feet deep. The mining height is approximately 13 feet, as the coal horizon contained a significant shale layer that averaged between 3 and 6 feet thick and there was 4 to 5 feet of coal on the top and bottom of the shale layer. The entry spacing is 95 feet, the crosscut spacing is 95 feet, and the crosscut angle is 90 degrees. The pillars, which are approximately two months old, are 75 feet by 75 feet, and the entry width was measured at 19 and 20 feet. MM&A estimates that the maximum overburden was approximately 1,800 feet for the sections mined to date.

The operator followed the pillar plan. Three factors made this inspection unique: first the mine operator allowed only one individual to operate the MRS units while in the pillar line. Second, the sequence of extraction was left-center-right, and two of the four MRS units were equipped with the load measuring system, which indicates changing loads by a light sequence system. Generally, the units indicated a constant load condition (green light) during pillar mining. Upon initial set of the MRS units for a new cut, the closest MRS indicated a condition of increasing load (yellow light), but this changed to a constant load condition (green light) soon after the pillar split was started. Lastly, seams both above and below the mine No. 34 were mined previously. The overlying seams were more than 400 feet above the Darby seam and were not anticipated to have any pressure differential effect. However, the Kellioka seam, which is 65 feet below the Darby seam, was previously mined and extensive areas were extracted using retreat mining. To minimize the impact of any multi-seam interactions, the mine operator columnized the mine development in the Darby seam, that is the entries and pillars in the Darby seam were directly over the entries and pillars in the Kellioka seam. The columnization was not exact in all areas, but significantly close that there were only minimal impacts observed in the Darby seam from the undermined Kellioka seam. There was no evidence in the pillars or in the roof indicative of high stress conditions.

5.6 *General Observations from the Site Visits*

Based upon the MM&A site visits, several observations are worthy of note.

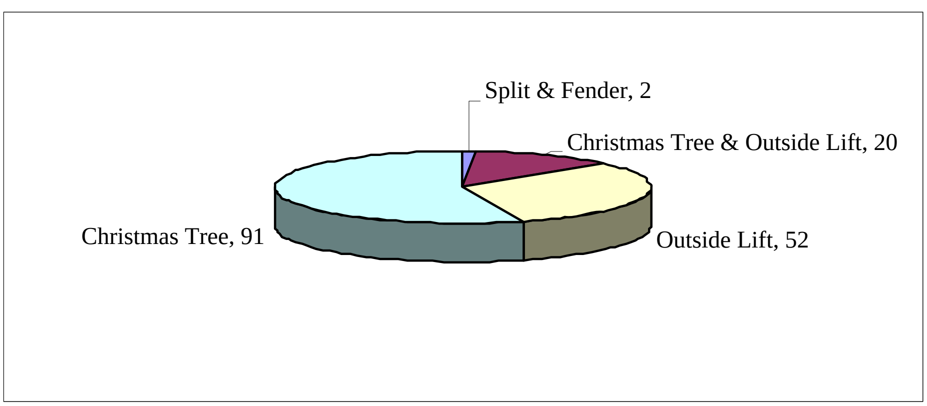
- The sequence of extraction was followed at all of the mines in accordance with the pillar plan.
- Equipment operators remained in positions that were considered relatively safe and provided minimum exposure to hazardous conditions. The field of view for the continuous miner operator is at times constrained, especially when cutting to the right. However, retreat of the continuous miner to a position outby the pillar corners permitted all operators the ability to view the cut from a safe distance.
- At MRS operations, both mines had a practice of assigning operation of MRS to only one individual at a time. A designated operator moved the machines with a remote control and only relinquished control of the remote when maintenance was required.
- Geology was not observed to be a factor at any of the mines. Observation of the cave, the stability of the pillars, and the condition of the roof did not indicate where any difference in geology impacted the method of retreat mining or the supplemental support methods used.
- The depth of cover was reported to be an issue at locations in one of the mines, but was not observed to be an issue at the other operations visited.
- Impacts to floor and ribs could be observed where there were abandoned mines within 100 vertical feet of the seam being mined. In one mine, columnization helped alleviate some of the observed stress conditions, whereas in another mine it was not possible to columnize and did not benefit the active mine.

Part 6. Retreat Mining Methods In Kentucky

This section presents a review and evaluation of the retreat mining and roof control plans of 34 coal mines, which represents about one-third of coal mines with approved retreat mining plans in Kentucky. The 34 coal mines reflect the operations which were actively engaged in pillar retreat mining at the beginning of the study period. The retreat mining plans of the 34 coal mines investigated in Kentucky are categorized and discussed in this section.

6.1 *Method of Extraction*

MM&A reviewed the plans in terms of pillar extraction method. Only two mines adopted a single retreat mining plan. The remaining 32 coal mines each utilize between 2 and 17 different pillar recovery plans. There is a total of 165 pillar plans for the 34 mines. An individual coal mine may incorporate multiple different pillaring plans due to various reasons. For example, Outside Lift plans are typically only used when the pillars are less than 40 feet wide. If deeper cover requires increased pillar dimensions, the mine may use Christmas Tree or Split and Fender methods to achieve a similar pillar recovery ratio. Several plans might also be necessary to accommodate changing seam and roof conditions or to respond to equipment problems (like an inoperable MRS unit). In other cases, it appears that multiple plans were needed to accommodate various equipment types (e.g., one section uses shuttle cars, another uses continuous haulage). At other mines, different plans were developed for various support types (e.g., timber vs. mobile roof supports).

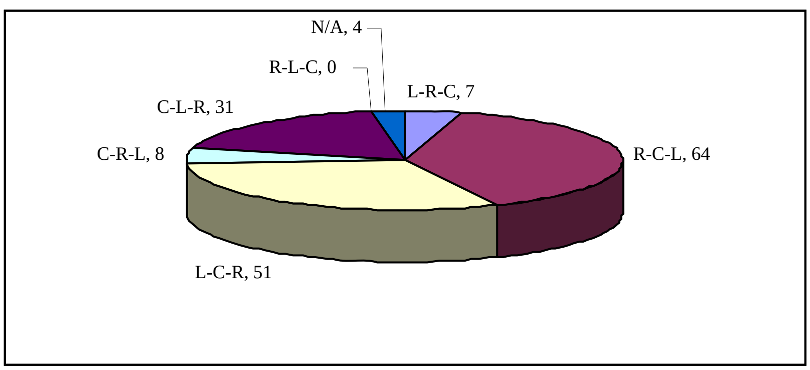


Pillar Recovery Methods for Pillar Plans from 34 Mines

As shown in the chart above, the most popular methods of pillar recovery utilized at the subject mines were those which required no additional roof bolting during retreat. The Christmas Tree method was used in 91 plans or 55 percent of the 165 pillar recovery plans incorporated by the subject coal mines; 32 percent or 52 plans use the Outside Lift method with or without push lifts; and 12 percent or 20 plans adopt a combination of Christmas Tree and Outside Lift methods transporting coal either with continuous haulage or shuttle car. Noticeably, the Split and Fender method was only practiced at two of the total reported pillar recovery plans, or 1.2 percent of the coal mine plans reviewed in this study.

6.2 *Sequence of Pillar Extraction*

The sequence of pillar extraction has an impact on stress distributions in the roof and in the pillars, as well as roof convergence and the rate of convergence, depending upon the sequence of extraction. The vast majority of the pillar plans reviewed extract the line of pillars left to right, or right-to-left, as shown in *Appendix Table 3*, and summarized in the figure below. Several plans extract the center pillar first and then extract the pillars to the right or left. This is typically done where two continuous miners are working on the same production panel in a supersection arrangement, or where continuous haulage is used. There are seven pillar plans where the center pillar is removed last (L-R-C in the figure below) and each of these mines is using continuous haulage, which specifically benefits this sequence of extraction.

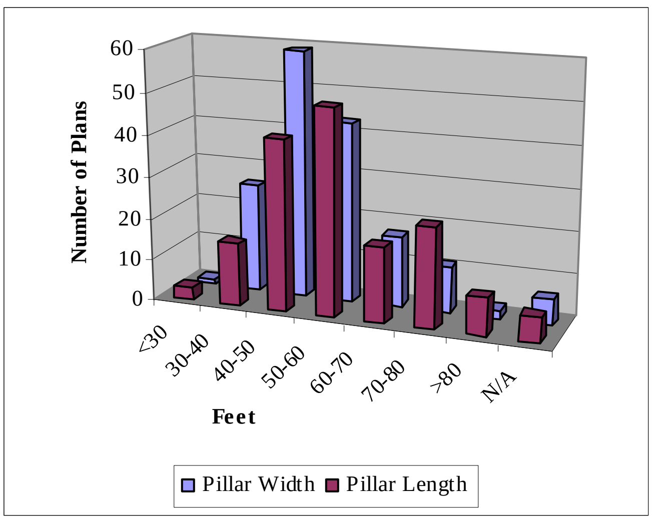


Sequence of Pillar Extraction for Pillar Plans from 34 Mines

6.3 *Size of Pillars*

The size of the pillars extracted has an impact on general mine stability, stress distributions in the roof and in the pillars, as well as roof convergence and the rate of convergence depending upon the number of pillars in the production panel. Pillar width is defined as the width of the pillar between entries, and the length of the pillar is the distance between crosscuts. It is typical of mines that advance production panels specifically with the intent of practicing retreat mining that the pillar lengths will exceed the pillar width by more than 20 percent in order to maximize the amount of coal removed per pillar and to improve the geometry of mining the pillar, while leaving sufficient coal to maximize roof stability.

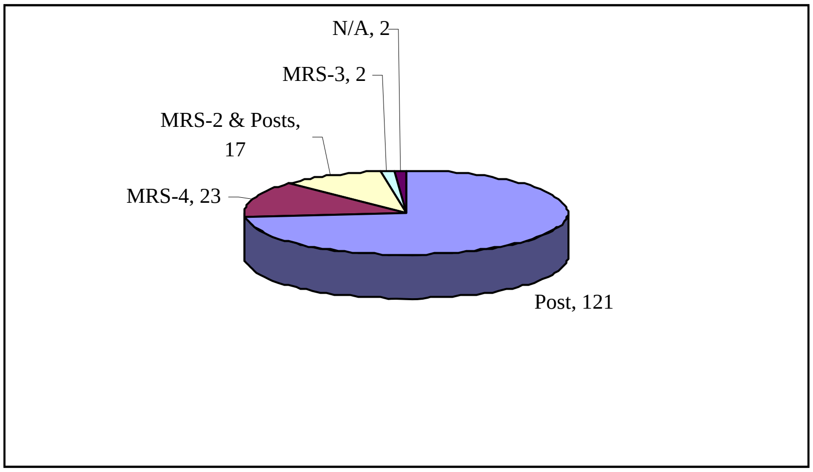
As shown in the figure below, the average size of pillar widths is less than 50 feet, and the average length of pillars is less than 60 feet. As indicated, the length of the pillar exceeds the width by observing the increased number of plans with pillar lengths greater than 60 feet.



Size of Pillars Extracted in Pillar Plans from 34 Mines

6.4 *Type of Supplemental Support*

In Kentucky, MRS has been utilized in some of the retreat mining coal mines. Of the 165 pillar extraction plans submitted by the 34 active retreat mining coal mines, 121 (75 percent) of the plans use wood posts as supplemental roof support. The remaining 42 plans in 10 mines use either four MRS units or a combination of MRS and wood posts as supplemental roof support during retreat mining, as shown below.

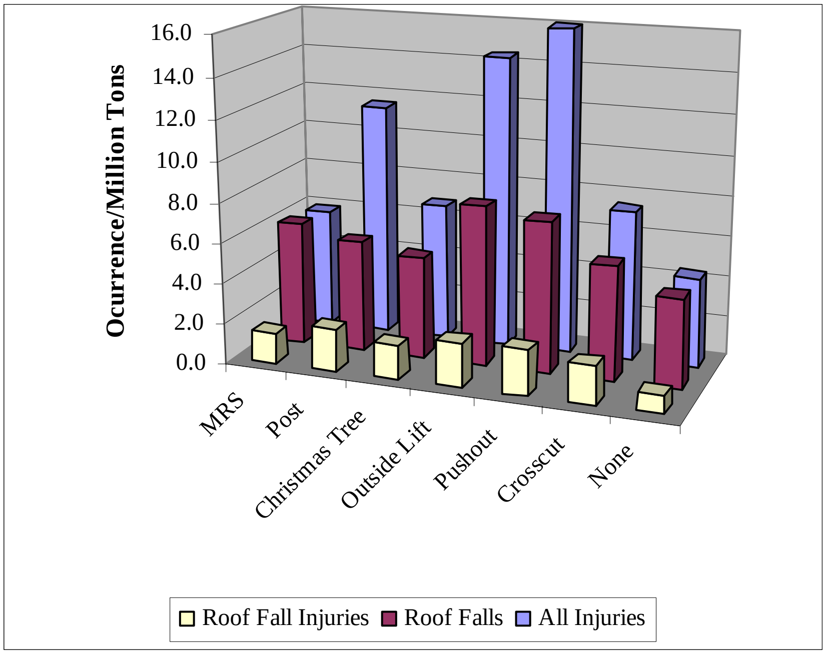


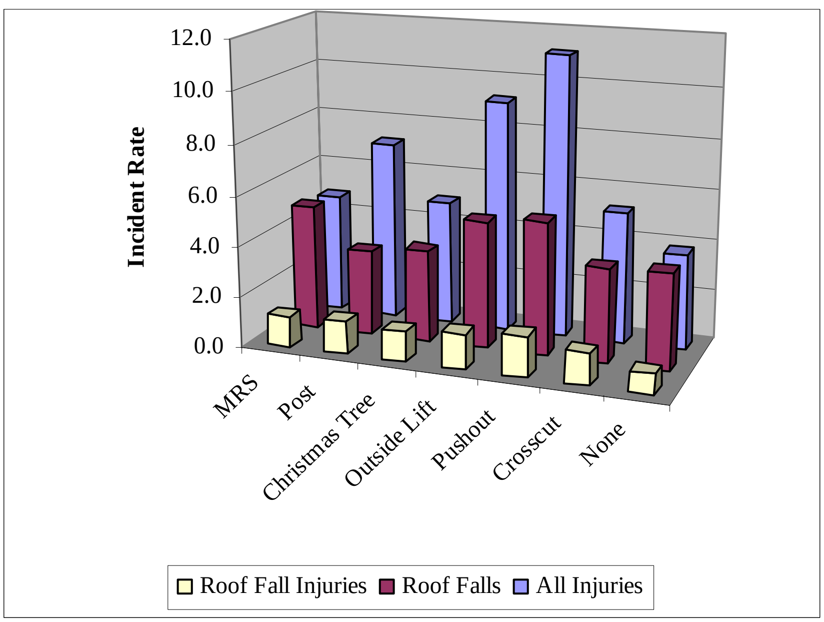
Sequence of Pillar Extraction for Pillar Plans from 34 Mines

6.5 *Safety Comparison of Retreat Mining Methods*

The primary impact of retreat mining is the effect of roof collapse (caving of the overlying strata) in the pillar extraction area. Uncontrolled caving or unpredicted roof falls outside the pillar removal area and into the area where personnel are working can lead to injuries and potential loss of life. Several factors leading to roof falls have been identified, including 1) pillar failure, (2) pillar yielding, (3) mine seismicity (earthquakes), (4) geologic structures, (5) panel layout designs, and (6) mining method. The actual ranking of factors depends upon local parameters. For example, mine seismicity pertains to tectonic activity like earthquakes, and is not a factor in Eastern Kentucky, but would be a consideration in the western U.S. Pillar failure and pillar yielding will be discussed as part of a subsequent section on pillar and panel design requirements. The relationship between roof falls and mining methods and immediate support was reviewed as part of this study. Serious roof fall injuries, reported roof falls, and total reportable injuries were compared with different mining methods. Roof falls and total reportable injuries are for all mining in the respective mines, regardless of how much production and man-hours relate to pillar work and how much relate to development. The first figure below summarizes statistics for the period January 1, 2004 through September 30, 2005, for the 34 mines in the study. The second figure compares the number of total reportable injuries

(Injuries), the number of reportable roof falls and the number of reported serious roof fall injuries as a function of the type of supplemental support used (wood posts or MRS), the type of retreat mining system (Christmas Tree or Outside Lift) and the method of extracting the end of the pillar (mining the *pushout*, taking cuts from the *crosscut*, and leaving the chevron pillar intact, *None*). The first figure compares the occurrences per million tons of production, while the second figure compares the occurrences per 200,000 man-hours of exposure.





It should be observed that all the differences noted above and explained below may be due to geological conditions between the different mines, and/or to the implementation of specific type of retreat mining, rather than the method or practice of retreat mining, itself. Upon examination of the number of the total reportable injuries (blue bars) per million tons of production and per 200,000 man-hours, it is noticeably higher for post supported retreat mines than for MRS usage. The number of total reportable injuries per million tons of production and per man-hours of exposure for Christmas Tree retreat mining is noticeably lower when compared to the Outside Lift method. Of significance is the relatively higher occurrence per million tons of production and per 200,000 man-hours of exposure for mines removing the pushout stump. It is more than a factor of three times higher than just mining lifts from the crosscut.

A comparison of lost time accidents directly attributable to roof falls or falls of rock from the roof or rib (yellow bars) shows only slight differences between MRS usage versus wood posts, there is a slight increase per million tons of production, and only a slight difference per man-hours of exposure. Accidents directly attributable to roof falls are slightly higher for Outside Lift mining than for the Christmas Tree method. Again, mines that extract the pushout stump have a significantly higher rate of occurrence in both comparisons.

When examining reportable roof falls (red bars), the number per million tons of production is noticeably higher for MRS usage than for wooden posts, and similarly higher per 200,000 man-hours of exposure. The occurrence of roof falls appears lower for the Christmas Tree method than for mines practicing Outside Lift. Of importance is the significantly higher roof fall rate for mines extracting the pushout stump.

Based on the above, two significant observations can be made. The first observation is the high incident rates for mines extracting the pushout stump. The incident rate is significantly higher than other methods. As explained earlier, the removal of the pushout stump creates a situation where the most roof convergence is experienced in the intersection adjacent to the pushout stump and where the remaining and adjacent pillars experience higher loads and increased stress.

The second relates to the relatively higher incidence of total reportable injuries and roof falls for Outside Lift mining versus the Christmas Tree method. However, the number of roof fall injuries do not show the same trend. It should be stated that the Outside Lift method is mining adjacent to the caved area (gob) and should experience a higher incidence of reportable roof falls, than the Christmas Tree method. The difference, therefore, is coincidental with the method of mining, and rather than a precursor of more significant problems, the difference suggests problems with geology or equipment application.

Part 7. Evaluation of Current Training

7.1 *Topics Covered in Annual Refresher Training*

Miners receive annual retraining. In accordance with Title 30 Part 48 of the Code of Federal Regulations (*CFR*) 8-hour refresher training must be given once every calendar year. 805 KAR7:030 Annual Retraining provides for all miners to receive 16 hours of annual retraining, 8 hours of which must be classroom hours, with the balance to be administered in segments of not less than 15 minutes. A review of the training plans for the 8-hours of classroom training submitted by the 34 mine operators identifies two factors that are worth commenting, the length of training devoted to roof control and the topics intended to be covered. During the classroom training period, the trainer devotes approximately 1.0 hour to the general topic of underground roof control. However, that same hour is also identified for the review of other topics including ventilation, emergency evacuation, firefighting, and other issues. A summary of the 8-hour training plans is summarized in *Appendix Table 9* and shown below.

Training Subjects	Number of Mines	%
2	3	9%
3	10	29%
4	14	41%
5	2	6%
Not Listed	5	15%

The summary indicates that 76 percent of the mines attempt to cover three or more subjects during the one hour period devoted to roof control in the classroom training.

7.2 *Sources of Training Materials*

Training materials are developed by MSHA and distributed through its Training Academy in Beckley, West Virginia. A review and discussion with Academy personnel and other MSHA staff personnel identified that the only training materials devoted to retreat mining is a "Best Practices" one-page summary (see *Appendix*). Available training materials regarding roof support and identifying geologic hazards are listed separately in the *Appendix*. Only 4 items are directly applicable to this topic and their age varies from 3 to 19 years old. Other training materials may be applicable but are either out of date or are videos without supporting written documentation. Although there are other training materials available, most of these are either role play type exercises, eye witness testimony, or are incidental to roof support and geologic hazard identification. In summary, applicable training materials devoted to roof control, identifying geologic hazards, and unsupported top are more than 10 years old and require updating.

Part 8. Recommend Practical Methods to Improve Safety

8.1 *Review of Kentucky Retreat Mining Accidents*

The researchers reviewed the four most recent fatal roof fall accidents in Kentucky that occurred during retreat mining between October 24, 2003 and August 3, 2005. The synopses below are extracted directly from the accident reports issued by MSHA.

(a.) Stillhouse Mining LLC – Mine No. 1 – August 3, 2005
(MSHA Report No. CAI-2005-11-12)

Stillhouse Mining LLC's Mine No. 1 is located near Cumberland, Harlan County, Kentucky. Coal is produced on the first and second shift, with maintenance being conducted on the third shift. The mine produces approximately 5,000 tons of raw coal daily using the room-and-pillar method. At 9:30 PM on Wednesday, August 3, 2005, Russell Cole, a 39-year old Section Foreman with 11 years mining experience, and Brandon Wilder, a 23-year old Scoop Operator with 36 weeks mining experience, were fatally injured at Stillhouse Mining LLC's Mine No. 1.

The second shift crew was conducting retreat mining on the 003 Mechanized Mining Unit (*MMU*). After mining the final lifts of a pillar, the crew was moving the four MRS units to the next location to be mined. While they were moving the MRS units, a roof fall occurred in the intersection. Eyewitnesses reported that Cole and Wilder were last seen standing beside the No. 2 MRS inby the intersection. After the fall, workers called out to Cole and Wilder, but there was no response. Wilder's body was recovered on Thursday, August 4, 2005, and pronounced dead by Harlan County Deputy Coroner Gerald Scott at 5:30 AM. Cole's body was recovered on Sunday, August 7, 2005, and pronounced dead by the Deputy Coroner at 7:18 AM.

The accident occurred because of a confluence of factors. The lift sequence for extraction of pillars in the Approved Roof Control Plan was not complied with on the 003 MMU. Mine management (1) failed to comply with additional safety precautions for the use of MRS units contained in the Approved Roof Control Plan while retreat mining was being performed, (2) failed to adequately train all personnel working on the 003 MMU in pillar recovery methods while using the MRS systems, (3) failed to adequately support the roof where persons were required to work or travel following the detection of a separation in the mine roof, at 11 feet 5 inches up into the roof in the intersection which collapsed resulting in the fatal injuries, (4) failed to correct the hazard presented by the separation or to post the intersection with a conspicuous danger sign to prevent miners from entering the area and being exposed to a hazard, (5) exposed miners to hazards related to faulty pillar recovery methods on the 003 MMU by having miners travel inby an area of second mining, and (6) failed to ensure that all personnel were task trained in the operation of MRS units.

(b.) **Reedy Coal Company, Inc. – Mine No. 25 – August 2, 2004**
(MSHA Report Number CAI-2004-15)

At 3:50 PM on Monday, August 2, 2004, Jimmy W. Anderson, a 38-year old Roof Bolter Operator with 14 years of mining experience, was fatally injured at Reedy Coal Company's Mine No. 25. Anderson and the section crew had just finished setting timbers for retreat mining and were observing the roof during the final pushout when a roof fall occurred in the No. 2 entry, resulting in fatal injuries. Anderson was located in the intersection of the No. 2 entry at crosscut No. 20 inby the turn posts. The fall ranged from 0-60 inches in thickness, 18 feet wide, and started at the center of the No. 2 entry intersection and extended inby for an undetermined distance.

The accident occurred as a result of hazardous roof conditions on the working section not being corrected. An elongated crack parallel to the right rib extended into the No. 2 entry intersection. A hillseam was present in the right crosscut running parallel with the No. 2 entry. The parallel joints, combined with the extraction of coal, allowed the roof fall to initiate inby the pillar line and to propagate outby to the No. 2 entry intersection at crosscut 20. The contributing factors were: failure to follow the approved roof control plan; the victim's position was prohibited by the provisions of the approved roof control plan. The day shift foreman failed to alert the oncoming shift of the hazardous conditions by not recording hazardous conditions found.

(c.) **Bell County Coal Corporation – Coal Creek Mine – June 16, 2004**
(MSHA Report No. CAI-2004-13)

At 7:30 PM on Wednesday, June 16, 2004, Edwin R. Pennington, a 25-year old contract worker, was fatally injured at Bell County Coal Corporation's Coal Creek Mine in a roof fall accident on the 004/003 pillar section. He was employed by Carol Dale Contracting Company working as a Shuttle Car Operator/Timber Man with five years and six months of mining experience. The accident occurred while retreat mining was being conducted on the 004/003 MMU.

At approximately 7:00 PM, the 003 MMU continuous mining machine was retreat mining in the pillar block located along the left side of the No. 5 entry. The mine roof started working in the worked out area of the pillar line and the continuous mining machine was backed outby approximately 60 feet in the No. 5 entry. David S. Goins, Continuous Mining Machine Operator; Donnie Lemarr, Continuous Mining Machine Helper/Timber man; and Bill Wilder, Charles Phelps, and Edwin R. Pennington, Shuttle Car Operators, were observing the mine roof working and the timbers taking weight. Pennington had his personal Quasar Model VM-L153 digital video camera and was filming the activities that were taking place. At approximately 7:30 PM, it was observed that the mine roof was working along the No. 5 entry outby the active pillar line and a roof fall was imminent. Goins started to move the continuous mining machine from the No. 5 entry into the connecting crosscut toward the No. 6 entry. Pennington and Lemarr were located in the No. 5 entry, just outby the continuous mining machine. They ran in an outby direction in an attempt to escape. The roof fall began in the worked out area and extended outby in the No. 5 entry for approximately 210 feet, trapping Pennington under the fallen material. After the fall, the workers called out to Pennington, but there was no response. Pennington's body was recovered on Thursday, June 17, 2004, and he was pronounced dead by Deputy Coroner Bill Bisceglia at 3:24 AM.

The accident occurred because hazardous roof conditions on the working section were not corrected. Two large vertical joints (commonly referred to as hillseams) running parallel to both ribs were present in the No. 5 entry. The parallel joints allowed the roof fall to initiate near the pillar line and propagate outby in the No. 5 entry.

(d.) Roblee Coal Company – Hacker's Creek Mine No. 1 – October 24, 2003
(MSHA Report No. CAI-2003-28)

On October 24, 2003, at approximately 10:20 AM, Richard Harlan II, a 29-year old classified Utility Man working as a Timber Man, was fatally injured in a roof fall accident in the 1-Left pillar section.

Between 10:00 and 10:15 AM, the continuous mining machine (continuous miner) was backed outby the pillar line after completing No. 20 pillar block and was being moved toward the right side of the section to begin mining block No. 21. Harlan and Ryan Jeran, Section Electrician, set three breaker posts in the No. 1 entry just outby the No. 20 block, when the roof began to work and fall behind the gob curtains in the No. 2 entry. Harlan and Jeran walked from the No. 1 entry to the No. 2 entry gob curtain between blocks 31 and 32. They observed that the fall had knocked out the inby row of breaker posts in the No. 2 entry. Harlan and Jeran traveled outby to the intersection of the No. 2 entry in the No. 9 row of crosscuts. Harlan and Jeran heard the roof beginning to work again. Jeran observed Harlan run toward the right side of the section through the No. 3 intersection of the No. 9 row of crosscuts where the roof collapsed on him. Jeran and other members of the crew yelled for Harlan, but there was no response. The crew installed timbers around the fall and notified John Murphy, Outside Man, of the accident. Harlan's body was recovered at 8:15 PM. Harlan was pronounced dead by Coroner Keith Queen at 8:45 PM.

The accident occurred because hazardous roof conditions on the working section were not identified and corrected. A near vertical, weathered, stress-relief joint on the left side of the No. 3 entry resulted in a detached block that cantilevered from the opposite side pillar. Abutment pressures from second mining, in conjunction with a fall that originated in the pillared area and that overrode the breaker points, caused failure of the cantilevered beam.

(e.) MM&A Commentary

All four accidents identified that there was a general failure to follow the roof control plans. In addition, the importance of identifying and classifying geologic hazards in the mine roof is essential for miner safety. The report raises the question, if there is sufficient training for miners to be able to identify serious roof conditions and take proper precautions? The accidents also identify that miners have tremendous overconfidence concerning the ability of MRS units to support the roof over a wide area.

8.2 *Recommendations on Roof Fall Fatal Accidents*

A review of the nine most recent roof fall fatal accidents prior to the initiation of the study identified 45 separate recommendations regarding the causes of the fatal accident and preventative measures to be taken. These recommendations are summarized in *Appendix Table 12* and below. The two most common recommendations in the MSHA fatality reports were: "Be alert for changing roof conditions and install roof supports where necessary" (8 of 9 Fatality Reports), and "Conduct a thorough visual examination of the roof, face and ribs and ensure permanent supports are installed prior to performing work …" (7 of 9 Fatality Reports). If the recommendations are classified according to four basic areas of Geology, Work Plan, Regulations, and Engineering, an interesting pattern is identified.

Category	General Description	Number of Recommendations
Geology	Need to identify geologic changes including changing strata and cracks	14
Work Plan	Related to knowledge of plans and need for observation	19
Regulations	Specific section of the State and Federal regulations that were violated	8
Engineering	Related to the design of the retreat mining sequence	3

The majority of the recommendations regard the knowledge of geology and the mine plan, which suggests that training and education at the mines experiencing these fatalities was insufficient. The recommendations regarding regulation and engineering indicate that approximately 25 percent of the causes of fatalities are related to those factors. Both areas need to be addressed to eliminate fatalities due to roof falls.

(a.) Comparison of MSHA Safety Statistics

A comparison of the accident and injury statistics published by MSHA was conducted for the 34 mines involved in the study. A summary of the statistics is presented in the *Appendix Table 7* and summarized in the following table for production through the 3rd quarter of 2005.

	YTD 3rd Quarter 2005						
District	**Mines**	**Fatals**	**Man-hours**	**Tons**	**FIR**	**NFDL-IR**	**Manpower**
Barbourville	7	0	841,435	2,775,150	0.000	10.93	448
Harlan	8	2	830,422	2,855,222	0.482	5.54	455
Hazard	4	0	430,535	1,321,654	0.000	4.18	297
Martin	1	0	497,892	1,230,763	0.000	5.62	211
Pikeville	14	1	1,384,120	5,222,177	0.144	4.77	668
Total/Avg.	**34**	**3**	**3,984,404**	**13,404,966**	**0.151**	**6.27**	**2,079**
MSHA 1)		**10**	**59,396,648**	**277,029,099**	**0.034**	**5.68**	**35,753**

1) Underground Bituminous Coal Mines

The two accident statistic databases maintained by MSHA and utilized by this report are the fatal incidence rate (*FIR*) and the non-fatal days lost (*NFDL*) incidence rate (*NFDL-IR*). MSHA maintains these statistics by location, along with a national average inclusive of all similar mines.

MSHA accident statistics were identified and analyzed the 34 mines identified in this report. The average number of fatal accidents per 200,000 man-hours for the mines in this study is 0.151. The national FIR average for bituminous coal mines was 0.034 for the same time period.

A review of the statistics available from MSHA shows that the average NFDL incidence rate for the mines analyzed is between 4.18 and 10.93. The national NFDL incidence rate for bituminous coal mines is 5.68 for the same time period.

8.3 *Assess Parameters Contributing to Accidents*

In three of the five fatalities on MRS sections, miners have been killed because they were standing next to the MRS units in the active intersection after the pushout stump was being mined or after it was completed. Standing next to the MRS unit during retreat mining means the individual was beneath unsupported roof, a violation of state and federal regulations, and that standing next to the MRS unit exposes the miner to roof fall hazards due to the pressure exerted by the MRS on the roof. There is no practical reason to stand next to a MRS unit while the machine is used to extract a pillar because of its remote control capability.

During field tests in underground mines, NIOSH identified several factors that might adversely influence worker safety in an MRS section.

- Elimination of wood posts reduced a worker's ability to assess roof conditions.
- Overconfidence in the ability of MRS units to support the entire area caused some miners to choose unsafe operating positions.
- Use of MRS units on a routine basis under adverse geologic and mining conditions to recover reserves that were otherwise unmineable.
- All personnel should be positioned outby the active intersection during the last lift. If the final stump is recovered, four MRS units should be used, and two of them should be positioned to narrow the roadway through the intersection as much as possible.

Existing documents and MM&A's review of the fatal accident reports reveal that utilization of MRS units may give mining personnel overconfidence concerning the ability of MRS units to support the entire area. Such overconfidence most likely contributed to unsafe operating locations and actions chosen by workers.

8.4 *Provide Additional Recommendations Based upon Study*

(a.) Geology Requirements

The ability to identify geologic hazards underground is difficult even for the most experienced geotechnical engineer. Examination by visual means is often hampered by rock dust, poor visibility, and inadequate lighting. Knowledge of previous roof conditions at a mine either from borehole information or from underground roof bolt test holes, assists the local mine worker in identifying conditions that create hazards. Although some of the local geologic conditions have been discussed in this report, constant diligence underground is necessary. In addition, the roof control plan requires the operator to describe the immediate roof. The researchers found the information in the roof control plan to be too general to judge roof support requirements in high stress conditions during retreat mining. A single borehole may not be representative of a mine's total roof condition, and under certain circumstances, additional geological information is necessary to determine the impact of certain mining practices.

Two mining practices have been identified where additional geological information is needed to assess the appropriateness of the practice. The first is the geologic structure and lithology of the interval between overlying and underlying mines. When abandoned or active mines are within 100 feet (or 20 percent of the overburden depth) above or below, additional geologic information is needed to assess roof and pillar stability of the active mine. The second is the removal of the pushout stump during pillar recovery. Mining of the pushout stump is associated with mines having the highest roof fall incident rate and the highest accident rate. In addition, removal of the pushout stump subjects the roof in the intersection adjacent to the stump to the highest level of roof-floor convergence. The rapid acceleration of roof convergence is associated with roof falls. It is known that competent roof of relatively strong rock will have less of a tendency to cave than weak rocks. Therefore, the ability to remove the pushout stump and maintain safe conditions is subject to the roof geology and should be defined in the retreat mining plan.

Other activities a mine operator could consider in defining the geologic conditions of the roof involve notations during day-to-day operations. Some mines make a point of noting on a map the conditions of the roof bolt test holes during panel development so that on retreat, the notes can be compared to current conditions and aid in the delineation of potential unstable roof areas. Other companies employ geologists or geologic consulting firms to map the immediate roof and predict changes in lithology that may impact roof stability.

(b.) Training Requirements

The most common recommendations in fatality accident reports are 1) the need to identify geologic hazards before mining, and 2) the misunderstanding or lack of knowledge of the roof control and retreat mining plans. Improvements in both of these areas can be accomplished through additional training with appropriate training materials. At some of the mines visited, and from discussions with major out-of-state mine operators, additional task training in retreat mining is provided at the start or restart of retreat mining. This additional training was emphasized when a mining crew had not conducted retreat mining operations for a defined period of time. Some companies conducted this task training at an above ground location, specifically to review the retreat mining plan, discuss additional safety factors, and/or review changes in the mine. Continual reinforcement of retreat mining safety practices and plans is necessary to emphasize those procedures and requirements that may have either been forgotten or not recalled when workers are assigned to other tasks for a period of time. In addition, periodic training in the retreat mining plan should be conducted more frequently than just once a year. This periodic training should reinforce compliance with the roof control plan, especially if it is not part of the MSHA and State classroom annual refresher training.

(c.) **Plan Requirements – Personnel at the Face**

A primary issue during retreat mining is to minimize the number of personnel near the active pillar line. The use of MRS units, where height permits, allows equipment operators to use radio remote control and remain under supported top and away from the active pillar line. However, in mines that use wood posts for supplemental support setting of breaker posts and line posts needs to be timely and well coordinated to minimize exposure near the active pillar line. Although it would seem that training in the setting of wood posts is not required, observations during the site visits found some miners to take inordinately long to set the posts, not only slowing production but exposing them near the pillar line for a prolonged period of time. Coordination and teamwork is essential to minimize the time required to set breaker and line posts. This is also an issue when different plans call for different quantities of wood posts, as explained in the next section.

(d.) **Plan Requirements – MSHA and State Plans**

Currently, mine operators must obtain separate approvals of roof control and retreat mining plans from MSHA and KYOMSL. Although discussions are ongoing between the two agencies, the potential conflict of having potentially two different plans is sufficient to warrant comment in this report. Typically, MSHA approval is sought first by mine operators. In some cases, local roof control specialists at KYOMSL offices require additional standoff distances, additional posts, or elimination of certain pillar lifts for the company to obtain state approval. This creates a situation where new plans differ from old plans, and where the State requirements differ from the Federal requirements. A single plan should be approved by both agencies.

(e.) **Plan Requirements – ARMPS Calculations**

Currently, there is no requirement to report pillar safety factors or ARMPS safety factors. However, pillar strength and roof stability are directly related and should be considered in establishing a retreat mining program. ARMPS is critical to establish the stability of any retreat mining configuration. The use of the ARMPS program, which can be downloaded free from the NIOSH Internet web site, will provide the pillar safety factors for pillar arrangements before, during, and after retreat mining. The review of ARMPS' safety factors in this study observed a relationship between roof falls and roof fall accidents for mines with low safety factors. NIOSH's research has shown that where the depth of cover is less than 650 feet, a stability factor above 1.5 is a reasonable level to assure pillar stability in a global situation.

As to the pillar stability factor for deep mining, above 1,250 feet, there is no guideline that is theoretically well-founded and practically verified. However, a research geologist of Pittsburgh Research Laboratory of NIOSH, suggested a deep mine pillar design guideline of 0.75 based on his analysis of NIOSH retreat mining database. It can be considered as first approximation of design guideline, which should be tempered with other site specific variables deemed relevant based on past experiences and sound engineering judgment.

The pillar global stability factors of any ongoing or future retreat mining mine should be calculated and evaluated at various representative sites (different depth cover, panel width, pillar size, or crosscut angle) using the NIOSH approved ARMPS program. Such information will be important information for engineers to evaluate and determine if the designed pillar size is adequate for a particular mining situation.

(f.) <u>Plan Requirements – Over/Under Seam Mining</u>

Of the 34 retreat mining plans reviewed, 10 mines had abandoned or inactive mines less than 200 feet above or below the proposed retreat mining plan. The plans identified the presence of such prior mining but gave no indication of hazards associated with such mines. Hazards would include flooded mine works, barrier pillars that create stress conditions in the overlying/underlying seam, the risk of roof or floor collapse into the mine, and ventilation contamination. It was already identified that additional geological assessment of the intermediate strata be conducted when mines are within a specified interval. In addition, several mining companies operating mines in proximity to prior mining established mapping practices that are worth review in a regulatory setting. A definitive interval or interval criteria to initiate such additional reviews has not been defined due to a lack of research information on the topic.

MM&A would recommend an interval of 100 feet for mines less than 1,000 feet deep, or 20 percent of the overburden depth for mines greater than 1,000 feet deep, as a possible criteria for additional geology, mapping, and technical reviews. For example, if a portion of a mine requesting retreat mining is 1,500 feet deep and overmined in a seam 190 feet above, then the operator should submit additional geologic and mining information. If overmining or undermining is within the stated levels, then the following information should be provided:

- Operators should provide interval contours to the overlying or underlying mine works. In one mine reviewed in the study, the interval was listed on the mine map as being 70 feet above the mine requesting approval of its retreat mining plan. In actuality, the interval varied between 20 feet and 70 feet, suggesting that major roof stability or other mining issues could arise when the interval decreased to the minimum thickness. The map would show the thickness to the overlying seam with isopachs in intervals of 10 or 20 feet.
- The footprint of the overlying or underlying mine should be shown on the proposed mine plan to identify areas where retreat mining may be more hazardous due to potential stress, water infiltration, or roof stability problems. The map should show the projections of the proposed mining and the mining in the overmined or undermined seam with specific attention to caved areas is the previously mined seam. Barrier pillars and main entries can cause overburden stress to be concentrated, thereby impacting support in the seam to be mined. Areas that warrant further investigation include areas where high stresses occur, greater than 650 feet of depth, where barrier pillars exist in abandoned mines, and where weak rock exists in the interburden.
- Additional geology information should be requested, as identified above, to make sure the operator is aware of weak and strong rocks in the interburden between the seams. In certain circumstances where there is a lack of strong rocks in the interburden, columnization of mains, submains, and production panels may be necessary to lessen the impact of the stress conditions and should be explained as part of a retreat mining plan.

(g.) Plan Requirements – Pushout Stump

As demonstrated in some of the convergence studies presented herein, removal of the pushout stump exposes the intersection adjacent to the pushout stump to a broader spectrum of roof impacts than any other retreat mining practice or pillar lift. The size and stability of the pushout stump also has a large influence on the stability of the roof in the intersection. An undersized pushout stump can decrease the intersection roof stability by yielding before it is extracted. The decision to mine or leave the pushout stump is a function of the roof geology, roof lithology, retreat mining method, primary roof support, and extraction sequence. In addition, mines extracting the pushout stump have a higher frequency of roof falls, roof fall accidents, and total injuries. It is recommended that the minimum size of the pushout stump be established, and its size be enforced by requiring all operators to measure and mark the length of the stump on its exposed side in the intersection. NIOSH has published guidelines on the minimum stump size, but it is not established in federal regulations. The average pushout stump observed in the roof control plans is 8 feet on a side. If the pushout stump is removed, then supplemental support should be required in the intersection, specifically, when there is a lack of strong rocks in the immediate roof. Supplemental support should take the form of either cable bolts at a length sufficient to minimize roof convergence, or their equivalent, during extraction of the pushout stump.

(h.) <u>Plan Requirements – Supplemental Support</u>

Supplemental supports available are wood posts, wood cribs, longer roof bolts, cable bolts, truss bolts, and MRS units. Cable bolts, of proper length and installation, are equivalent to the double row of breaker posts installed in accordance with roof control plans and Kentucky regulations. Use of cable bolts as breaker posts provides greater visibility and freedom of access into and away from the pillar line.

(i.) <u>Plan Requirements – MRS Units</u>

This study has identified that, when possible, the use of MRS units instead of wood posts, is highly effective in reducing the risk of roof falls in pillar recovery, and of reducing roof fall injuries. However, they must be employed properly and operated safely. A set of operator guidelines is included in the *Appendix*. One key advantage of MRS is that it can be operated remotely, from safer locations. However, the more recent fatalities indicate that equipment operators have a tendency to stand next to or near the MRS units while in operation. In addition, miners overestimate the ability of the MRS to hold up the roof over a wide area. Consequently, more roof fall fatalities have occurred recently with MRS units than with the use of wood posts for supplemental support. Retreat mining roof control plans should include several provisions regarding the employing and implementation of MRS units for supplemental support.

All plans should include the provision that designates a single operator of all MRS units inby the pillar line. Once an MRS unit is moved outby the pillar line under supported roof, then alternate operators can be designated to move the units for relocation or maintenance repair.

All MRS units can be equipped with a visible load rate indicator that is currently offered as an option by the manufacturer. The load rate indicator, if attached to at least one machine in each pair, will give a visible warning of increasing load alerting all personnel of a possible impending roof fall. KYOMSL should evaluate the implementation of this technology to all mines using MRS units.

8.5 *Impact of Recommendations upon Industry*

The impact of implementing these recommendations is considered to be nominal upon the industry after the following reviews.

(a.) <u>Impact of Geology Requirements</u>

The ability to identify geologic hazards underground is critical to mine safety. The requirement to provide additional information in overmining and undermining situations during the mine plan approval process is prudent. In most instances, the data needed to prepare and describe the additional information is available preliminary core drilling. The cost to prepare this information as part of the roof control plan is estimated to be several mandays and therefore is not considered significant.

(b.) <u>Impact of Training Requirements</u>

Additional training takes time away from production. However, the additional task training time of several hours per quarter is far less than the loss in production associated with a fatality, in addition to the toll on families and the community. The benefits of training may result in increased production due to better coordination and teamwork. The increased cost is considered minor.

The ability to upgrade training materials to current standards, and to upgrade audio/visual presentation capability, requires funding and resources currently not available on the state level. Historically, access to updated training materials has been the responsibility of MSHA. Further investigation of this recommendation is necessary to determine the most appropriate source of funding and responsibility.

(c.) <u>Impact of Mine Plan Requirements</u>

The seven recommendations on plan requirements are intended to improve safety through the definition of pre-mining geology and mine conditions, and the implementation of certain underground mining practices. The cost of the additional time to perform pre-mining geology and adjacent mining is typically within the current information flow within a company. Its refinement and summarization is incremental to the cost of preparing a roof control plan for approval. The recommendations for changes to certain underground mining practices is again believed nominal as confusion and mistakes in current practices decrease production, and additional precautions may eliminate the errors and provide higher levels of profit.

Part 9. Review of Kentucky Statutes and Regulations

Kentucky statutes applicable to retreat mining include Kentucky Revised Statutes (*KRS*) Chapter 352.201 *Roof Control Plan*. Kentucky Administrative Regulations (*KAR*) applicable to retreat mining include 805 KAR 5:070 *Requirements for Roof Support and the Roof Control Plan Approval Process*.

The pillar recovery plan is part of the Roof Control Plan as required in KRS 352.201, and generally shows the sequence of cuts for the recovery of individual pillars and the sequence of pillar removal in a panel. The pillar recovery sequence normally shows the placement and sequence of roof support used during pillar extraction. In formulating pillar recovery plans, the mine operator should discuss proposals with the KYOMSL's district roof control specialist. The specialist will frequently identify requirements of the law and regulations, be able to suggest techniques that have worked for other mines under similar condition, and at the very least, input suggestions during the initiation process will ease the approval process of the plan during the later stages. Once again, closely working with the KYOMSL District officials is important. Federal laws differ from State laws and must also be considered, but will not be discussed in this report.

Kentucky statutes applicable to training include KRS 351.106 *Education and Training Program*, and applicable administrative regulations include 805 KAR 7:030 *Annual Retraining*, 805 KAR 7:050 *Task Training*, and 805 KAR 7:060 *Program Approval*. In some instances, Federal laws differ slightly from State laws and must also be considered, but will not be discussed in this report.

9.1 *Roof Control Plan Statues and Regulations*

KRS Chapter 352.201 *Roof Control Plan* identifies the need for a roof control plan, and establishes general criteria for safe practice and implementation. Retreat mining plans are included as part of the roof control plan.

The requirements in 805 KAR 5:070 have several sections that specifically address retreat mining: Section 7 *Pillar Recovery*, and Section 17 *Roof Control Plan Approval Criteria* (7) *Pillar Recovery*. Other roof control regulations applicable to the recommendations contained herein are Section 6 *Conventional Roof Support (Wood Posts)* and Section 16 *Roof Control Plan Information*.

The recommendations outlined in this report to improve safety by increasing requirements in the roof control plans should assist in identifying geological and hazardous situations in which operators would be required to identify those specific conditions that significantly impact retreat mining operations, and if necessary, increase supplemental support to minimize those impacts. These recommendations are believed within the administration of the KYOMSL and can be implemented within their purview.

9.2 *Training Statues and Regulations*

KRS 351.106 *Education and Training Program*, addresses the establishment of administrative standards for training, and directs the Mining Board to establish criteria and standards for a program of training, retraining, and reeducating all certified persons who work underground.

Administrative regulation 805 KAR 7:050 *Task Training* identifies the need for a miner assigned to a new work assignment to receive training in roof control and mobile equipment operations. The implementation of additional training identified in the recommendations can be addressed under this regulation. In addition, recommended training in identifying geological hazards should be included in all annual refresher training consistent with 805 KAR 7:030 *Annual Retraining*.

Administrative regulation 805 KAR 7:060 *Program Approval* provides for approval of all training plans by the Mining Board.

Part 10. Conclusions

Kentucky has suffered four mining fatalities between June 2004 and August 2005, during retreat mining operations in Eastern Kentucky mines. It is estimated there are over 100 mines with approved plans to conduct retreat mining in Eastern Kentucky, and these mines contribute between 33 and 50 percent of the 51 million tons of underground coal mined each year.

The Researchers recommend changes in the content and review of roof control plans to identify geological conditions and operating practices that require additional safety during retreat mining, and in task training requirements to address the changes that have occurred in the industry and to raise awareness and training of miners to a higher level that will improve safety. Based upon nature of these recommendations, the Researchers believe that these implementation can be accomplished within the current administrative regulations, and believe no legislative action is required. The recommendations detailed in *Part 8.4* of this report are summarized below, and are grouped into three categories: changes to the roof control plan, changes to the amount of geological information required, and changes in the training and retraining of miners.

1. Changes to Roof Control Plans

- **Minimize Workers Near the Active Pillar Line**

Minimizing the number of personnel near the active pillar line should be a primary goal in the review and approval of all retreat mining plans. The use of MRS units, where height permits, should be encouraged to move equipment operators away from the active pillar line and to remain under supported roof.

- **Coordinate MSHA and State Plans**

Complete implementation of a dual review and approval of the roof control plans by MSHA and the KYOMSL. This will eliminate the need for mine operators obtaining separate approvals of roof control and retreat mining plans from two agencies and eliminate the potential conflict of having two different plans.

- **Require ARMPS Calculations in Roof Control Plans**

Require roof control plans to report pillar safety factors and NIOSH's ARMPS safety factors in all retreat mining plans. Pillar strength and roof stability are directly related and should be considered in establishing a retreat mining program, and ARMPS is critical in establishing the stability of any retreat mining configuration.

- **Acquire Additional Information on Over/Under Seam Mining**

Of the 34 currently active Kentucky retreat mining plans reviewed, 10 mines had abandoned or inactive mines less than 200 feet above or below the proposed retreat mining plan. The plans should include additional geological assessment of the intermediate strata when abandoned or inactive mines are within a specified interval. In addition, mine operators should provide interval contours to the overlying or underlying mine works when abandoned or inactive mines are within a specified interval. A definitive interval or interval criteria to initiate such additional reviews has not been defined due to a lack of research information on the topic. MM&A would recommend a minimum interval of 100 feet or 20 percent of the overburden depth as possible criteria for additional geology, mapping, and technical reviews.

- **Increase Requirements When Mining Includes the Pushout Stump**

As demonstrated in some of the convergence studies presented herein, removal of the pushout stump exposes the intersection adjacent to the pushout stump to a broader spectrum of roof impacts than any other retreat mining practice or pillar lift. The decision to mine or leave the pushout stump is a function of the roof geology, roof lithology, retreat mining method, primary roof support, and extraction sequence. The minimum size of the pushout stump should be established, and its size should be enforced by requiring all operators to measure and mark the length of the stump on its exposed side in the intersection. Mine operators should define the immediate roof geology and install supplemental supports in the intersection, specifically when there is a lack of strong rocks in the immediate roof.

- **Allow Variations in Supplemental Support**

Allowing the use of cable bolts as breaker posts provides greater visibility and freedom of access into and away from the pillar line.

- **Restrict Equipment Operators on MRS Units**

All plans should include the provision that designates a single operator of all MRS units operated inby the pillar line. Once an MRS unit is moved outby the pillar line that is under supported roof, then, alternate operators can be designated to move the units for relocation, maintenance, or repair.

Each pair of MRS units should be equipped with a visible load rate indicator that is currently offered as an option by the manufacturer. The load rate indicator will give a visible warning of increasing load alerting all personnel of a possible impending roof fall. The KYDNR should develop guidelines for the implementation of load rate indicators on MRS units.

2. Changes to Geology Requirements

- **Geology Requirements in Over/Under Seam Mining**

Additional geological information is needed to assess the geologic structure and lithology of the rocks in the interval between overlying and underlying mines. When abandoned or inactive mines are within a specified distance, additional geologic information is needed to assess roof and pillar stability of the active mine. An outline of geology information to be requested and reviewed during the review process is provided in the exhibits attached to the report.

- **Geology Requirements When Removing the Pushout Stump**

Additional geological information is needed to assess the geologic structure and lithology of the immediate roof in the intersection adjacent to the pushout stump, when it is removed during pillar recovery. The ability to remove the pushout stump and maintain safe conditions is subject to the roof geology and should be defined in the retreat mining plan. An outline of geology information to be requested and reviewed during the review process is provided in the exhibits attached to the report.

3. Changes to Training Requirements

- **Training Requirements**

The most common recommendations in fatality accident reports are 1) the need to identify geologic hazards before mining, and 2) the misunderstanding or lack of knowledge of the roof control and retreat mining plans. Improvements in both of these areas can be accomplished through additional training with appropriate training materials. Additional task training in retreat mining should be required at the start, or restart of retreat mining. This additional training should be emphasized when a mining crew has not conducted retreat mining operations for a defined period of time. If the retreat mining is continuous over the year, then periodic training during the year should reinforce compliance with the roof control plan. This task training should be in addition to the MSHA and State classroom annual refresher training.

- **Improved Training Materials**

Training materials that specifically address retreat mining either do not exist, or are limited to safe mining practice dos and don'ts. The lack of suitable retreat mining training materials is related to the vast number of various retreat mining plans utilized in the industry. However, specific training modules that address various phases of the retreat mining should be reviewed, renewed, and updated for current practice, and current audio visual technology. Training materials should include, at a minimum, the following topics:

- Timbers – Quality Control of Posts
- Teamwork and Coordination of Installing Wood Posts
- MRS Operating Procedures
- Geology and Identification of Roof Hazards
- Proper Roof Bolting Techniques
- Red Zone Delineation of Hazardous and Unsupported Roof Areas

Tables

Kentucky Department of Natural Resources

Office of Mine Safety and Licensing

Documents List

Table 1

Study No.	Roof Control Plan	New Roof Control Plan	Revised Roof Control Plan	Roof Control Plan Supplement	Temporary Approval Roof Control Plan	Maps	Title 30 Part 48 Training Plans	Accident Reports
1	06/06/01		03/04/05			Yes		
2	07/19/05			05/20/05		Yes	08/14/01	Yes
3	06/13/05					Yes	04/30/96	Yes
4	02/22/05	07/07/04				Yes	09/23/05	Yes
5	09/16/05	05/10/05				Yes	01/14/05	
6	09/26/05		09/07/05			Yes	12/06/04	
7	07/28/05			10/13/05		Yes	04/15/97	Yes
8	09/10/01			10/5/04, 8/31/05		Yes	09/10/01	
9	03/08/00			05/07/04	08/31/05	Yes	01/23/04	Yes
10	08/27/98			11/20/03		Yes	06/17/02	Yes
11	12/26/97			09/08/05	08/29/05	Yes	07/28/05	Yes
12	10/24/03			06/08/05	08/02/05	Yes	11/17/03	
13	06/23/03			06/08/05	11/08/05	Yes	10/15/03	
14	10/12/99		08/04/03	08/26/03		Yes		
15	06/30/05			10/20/05		Yes	06/29/05	
16	04/18/05	12/18/97			09/16/05	Yes	05/20/02	
17	05/20/05	10/16/02				Yes	09/14/04	Yes
18	05/21/04					Yes		
19	11/24/03		09/13/02			Yes	08/13/03	Yes
20	07/27/05		08/05/03			Yes	09/09/04	
21	08/19/05		07/28/05			Yes	04/16/04	Yes
22	09/03/04	04/16/04				Yes	04/16/04	Yes
23	05/27/05		07/02/04			Yes	06/28/05	Yes
24	07/13/05		01/12/04			Yes	03/07/05	Yes
25	08/02/05		05/17/05			Yes	12/29/04	
26	07/15/05	04/14/03				Yes	01/27/03	Yes
27	09/28/05		09/16/05			Yes	07/16/04	Yes
28	07/15/05		10/04/01			Yes	01/29/03	
29	07/14/05		05/31/05			Yes	08/31/04	Yes
30	07/15/05		06/18/04			Yes		Yes
31	01/06/05		12/13/04			Yes	10/05/05	Yes
32	08/30/05		08/24/05			Yes	02/09/05	
33	07/12/05		02/12/01			Yes	09/19/97	
34	03/21/05					Yes		

Kentucky Department of Natural Resources

Office of Mine Safety and Licensing

Summary of Approved Roof Control Plans (Retreat Mining)

Table 2

Study No.	Maximum Cover (ft.)	Main Roof Type	Main Roof Thk (ft.)	Immediate Roof Type	Immediate Roof Thk (ft.)	Coalbed Seam	Coalbed Thk (in.)	Bottom Type	Bottom Thk (ft.)	Roof Bolt Minimum Length (ft.)	Resin Bolt Minimum Length (ft.)	Mines Below	Mines Above	Elevation	Depth of Cut (ft.)	Last Permanent Support	*Footnote No.*
1	1,100	SSH	10	SH	5	Buckeye Springs	32	SSH	10	3.5	3.5	Lower Mingo @ 1800	Hignite @ 2500 Stray @ 2250 Sterling @ 2150	1950	32	2nd Full Row	
2	1,200	SH/SS	22.2	SH/SS	22.2	Hazard #4 Fireclay Part	36 4-6			3.5	3.5	None	None	1140	44	2nd Row	
3	1,150	SH/SS streaks			22.2	Hazard Fireclay	36 4-6	SH/SS SS/SH	1.9 10.2	2.5	3	None	Hazard #7 @1710 Hazard #5A @1570	1170	44	2nd Row	
4	500	SS	30	SL	4-6	FC/HZ #4	48		10	3	3	None	None	1046	35	2nd Full Row	
5	300	SS	30	SS	30	Hazard #8	48	SH	10		3.5	None	None	1804	44	2nd Row	*1, 16*
6	700	SS	20	SH	2	Hazard #4	48	FC	1	3	3	None	None	960	40	2nd Full Row	
7	1,100	SH/SS SH	25 8	SH/SS SH	25 8	Hazard #4 Fireclay	40-120 4-6	SH/SS SS/SH	1.9 10.2	3.5	3.5	None	None	1180	40	2nd Full Row	*8*
8	1,300	SH	10	SH	10	Harlan	34	SH	10	3.5	3.5	None	None	1560	36	2nd Row	*11*
9	800	SSH	50	SH	10	Winifrede	60	SH	10	3.5	3.5	Darby @ 1780	High Splint @ 3140	2730	40	2nd Full Row	*10*
10	2,000	SS	10	SH	0-2	B Seam	48" with shale parting 6-12"	SSH	10	3	3.5	None	Darby @ 1600	1550	40	2nd Full Row	*10*
11	1,400	SS	10	SH	10	Upper Harlan	38" with shale parting 4-8"	SH	10	3.5	3.5	Upper Path Fork @ 1650 Harlan @ 1740	D Seam Darby @ 1975	1800	40	2nd Full Row	
12	845	SS	50	SH	10	High Splint	40	SH	10	3.5	3.5	Harlan @ 1390	None	2880	32	2nd Full Row	
13	600	SS	20	SS	6	Wallins	44	FC SH	1 10	4	4	Darby C @ 1700 Kellioka @ 1560	D Seam Pardee & L Pardee	2250	32	2nd Full Row	*13, 14*
14	1,700	SSH	50	SH	10	Harlan Upper Harlan	120 45	SH	3	3.5	4	None		1440	32	2nd Full Row	*15*
15	450	SS	40	SH/SS	10	Amburgy	48	SH	10	3.5	3.5	None	Hazard #7 @ 1710 Hazard #5A @ 1570	1035	40	2nd Row	
16	550	SS	40	SS	40	Hazard #5A	$48	SH Coal SH	0-2.4 0-.83 20	3.5	3	Hazard #4 @ 960	Hazard #9 @ 1600	1280	32	2nd Row	*6*
17	1,000	SS	74	SH	14	Elkhorn (#4)	36	FC/SH	1.6-44	3.5	3.5	None	Hazard #4 @ 990	780	44	2nd Row	*7*
18	600	SS/SH	8	SH SH	15 0-12	Hazard #4	50-70	SH	10	4	4	None	None	1540	40	2nd Row	
19	1,250	SH/SS streak		SH	10	Pond Creek	36-89	FC SH/SS	5 5	5	5	None	None		36	2nd Row	*12*
20	500	SL	100	SL	30	Elkhorn #2	40	SS	30	4	4	L Elkhorn @ 1360	Hazard #4 @2090 Elkhorn #3 1/2 @1660	1550	30	2nd Row	
21	650	SL	10	Coal Rock	2.5 1	Lower Elkhorn	40	SL	10	5	5	L Elkhorn @1400	Hazard #4 @ 2140 Elkhorn #2 @ 1590	1415	30	2nd Row	*9*
22	450	SS	40	SS	10	Elkhorn #3	48-60	SH	10		6	Elkhorn #2 @ 1435 L Elkhorn @ 1375	Hazard #4 @ 1950	1525	35	2nd Row	
23	375	SS		SS	10	Upper Alma or Lower Alma	36	SH/SS	10	4	3.5	Pond Creek @ 1222	None	1360	35	2nd Row	
24	400	SS			40	Clintwood	32	SS	10		3	Glamorgan @ 1040	L Elkhorn @ 1440	1240	35	2nd Row	
25	750	SS/SH	50	SS	8	Elkhorn #1	79	SH	10		4	None	Williamson @ 1360	1140	30	2nd Row	
26	500	SH		SSH	10	Elkhorn #2, #3	96	FC SL	.5 10		4	None	None	690	35	2nd Row	
27	600	SH/SS	50	SH		Elkhorn #2	47	SH		4	3.5	Pond Creek @ 685	None	845	30	2nd Row	

Kentucky Department of Natural Resources

Office of Mine Safety and Licensing

Summary of Approved Roof Control Plans (Retreat Mining)

Table 2

		Main Roof		Immediate Roof		Coalbed		Bottom		Roof Bolt	Resin Bolt						
Study No.	**Maximum Cover (ft.)**	**Type**	**Thk (ft.)**	**Type**	**Thk (ft.)**	**Seam**	**Thk (in.)**	**Type**	**Thk (ft.)**	**Minimum Length (ft.)**	**Minimum Length (ft.)**	**Mines Below**	**Mines Above**	**Elevation**	**Depth of Cut (ft.)**	**Last Permanent Support**	***Footnote No.***
28	500	SH	25.4	SH	3.1	Elkhorn #2	32	SSH	13		4	None	None	730	35	2nd Row	*5*
29	800	SS	60	SH	22	Elkhorn #3	42-46	SH	10		4	None	Amburgy @ 1635	1435	35	2nd Row	*4*
30	1,150	SS	60	SH/SS	10	Pond Creek	60	SH	10	4	4	None	Fireclay @ 1125 U Elkhorn #3 @1020 Williamson @ 970 Cedar Grove @ 915	700	40	2nd Row	*3*
31	1,050	SS	80	SH/SS	10	Elkhorn #3 Cedar Grove	44 48	SH SS	10 70	4	4	Pond Creek @ 445	Williamson @ 713	623	40	2nd Row	
32	250	SS	20	SS	20	Elkhorn #2	36	SH	15	3.5	4	None	Elkhorn #3 @ 1340 Amburgy	1298	30	2nd Row	*2*
33	400	SS	20	SS	5	Clintwood	36	SS	10		3	Glamorgan @ 950	L Elkhorn @ 1340	1130	30	2nd Row	
34	2,000	SS	10	SH	2-13	Darby	162	SH	5	3	3.5	Kellioka @ 1960	None	2010			

1) A 30-inch rod will be used in top that is of massive sandstone, but stop when cracks, soft places or slate top is encountered
2) 48-inch resin grouted rod or 42-inch resin roof bolt in firm sandstone with no defects
3) 48- inch resin grouted rod or 42-inch resin grouted rod on panels less than 3,000 feet in length
4) 48-inch resin grouted rod except 60-inch resin grouted rod on additional openings
5) 60-inch resin grouted bolt applies to area affected under body of water permit
6) Average seam thickness 48 inches
7) No. 4 @ 990 feet
No. 5A @1310 feet
No. 7 @ 1390 feet
No. 9 @ 1590 feet
8) Average seam thickness 84 inches
9) Split ventilation extended cut pillaring: 35 foot depth
10) 32 feet with 21 SC center driven haulage
11) ARMPS supplied
12) Active 800' above:
Pegasus 10219-62
Black Bear 10219-24
Black Bear 2 10219-54
Red Fox 1 10219-37
Red Fox 2 10219-43
Red Fox 3 10219-48
13) KRCC #4 (Kellioka) @ 1660
KRCC #5 (Darby) @1700
Arch #37 (Harlan) @ 1390
14) Clover Splint Mine (High Splint) @ 2960
Royal Darby #2 (Low Splint) @ 2820
Clover Darby Coal (Pardee) @2560
15) "B" Mine (Kellioka @ 1595
Mine (Darby) @ 1625
Mine (Owlseam) @1675
16) 42-inch resin grouted rod or 30-inch resin grouted rod in massive sandstone

Legend
FC = Fire Clay
SH = Shale
SS = Sandstone
SSH = Sandy Shale

Kentucky Department for Natural Resources

Table 3

Office of Mine Safety and Licensing

Approved Roof Control Plans (Retreat Mining)

Table 3

Study No.	Plan	No. of Entries	Method of Support	Sequence	No. of CM's	Coal Haulage	Pillar Dimension Width (ft.)	Pillar Dimension Length (ft.)	Retreat Type	% Remaining	Angle of Crosscuts	Pillar Split Width (ft.)	Rib Cut Depth (ft.)	Pillar Split	Comments
1	A	9	Post	R-C-L	1	SC	50	50	CT	36%	90	11	32	Crosscut	
	B	9	Post	C-R-L	2	SC	50	50	CT	36%	90	11	32	Crosscut	
	C	9	Post	C-L-R	2	SC	50	50	CT	28%	90	11.5	32	Crosscut	
	D	9	Post	C-R-L	2	SC	50	50	CT	28%	90	11.5	32	Crosscut	
2	A	5	Post	C-L-R	1	SC	40.4	36.9	SS	17%	60	12	44	Pushout	Entries 1 and 5 are 11.5' wide
	B	5	Post	C-L-R	1	SC	40.4	36.9	SS	17%	60	12	44	Pushout	Entry 1 is 11.5' wide
	C	5	Post	C-L-R	1	SC	40.4	36.9	SS	17%	60	12	44	Pushout	All entries same width
	D	--	Post	--	1	SC	50.5	60	SS	--	60	12	44	Pushout	Removal of barrier pillar only
	E	5	MRS-2 & Posts	C-L-R	1	SC	40.4	36.9	SS	17%	60	12	44	Pushout	
3	A	5	Post	L-C-R	1	CH	40.4	31.9	SS	8%	60	11.5	44	Pushout	
	B	5	Post	L-C-R	1	CH	39.3	36.9	SS	8%	60	11.5	44	Pushout	
	C	5	Post	L-C-R	1	CH	40.4	26.9	SS	13%	60	10	40	Pushout	
	D	5	Post	L-C-R	1	CH	40.4	26.9	SS	13%	60	10	40	Pushout	Plan for mining second panel where no GOB exists on the side of the panel
	E	3	Post	C-R-L	1	CH			SS	17%	60	11.25	44	Crosscut	Plan does not give pillar dimensions
	F	5	Post	C-L-R	1	CH	40.4	36.9	SS	17%	60	12	44	Pushout	Entries 1 and 5 are 11.5' wide
	G	5	Post	C-L-R	1	SC	40.4	36.9	SS	17%	60	12	44	Pushout	All entries same width
	H	5	Post	C-L-R	1	SC	40.4	36.9	SS	17%	60	12	44	Pushout	Entry 1 is 11.5' wide
	I	--	Post	--	1	SC	50.5	60	SS	--	60	12	44	Pushout	Removal of barrier pillar only
4	A	11	Post	R-C-L	1	SC	40	40	SS	39%	90	11	35	Crosscut	
	B	11	Post	R-C-L	1	SC	40	40	CT	41%	90	11	30	Crosscut	
	C	11	Post	R-C-L	1	SC	50	50	CT	50%	90	11	35	Crosscut	
	D	11	Post	R-C-L	1	SC	40	25	SS	38%	90	11	35	Crosscut	
	E	11	Post	R-C-L	1	SC	40	40	CT	41%	90	11	30	Crosscut	
	F	11	Post	L-C-R	1	SC	40	40	CT	38%	90	11	30	Crosscut	
5	A	5	Post	C-L-R	1	CH & SC	35	35	SS	23%	90	11.5	45	Crosscut	
	B	7	Post	L-C-R	1	CH & SC	60	60	CT	23%	90	11.5	35	Pushout	
6	A	11	Post	R-C-L	1	CH	40	40	SS	32%	90	20	40	Crosscut	
	B	9	Post	R-C-L	1	CH	40	40	SS	32%	90	20	40	Crosscut	
	C	11	Post	C-L-R	2	CH	40	40	SS	32%	90	20	40	Crosscut	
	D	11	Post	C-L-R	2	CH	40	40	SS	53%	90	20	40	--	Difference in rib cut
	E	11	Post	C-L-R	2	CH	40	40	SS	53%	90	20	40	--	Difference in rib cut
	F	11	Post	C-L-R	2	CH	40	40	SS	53%	90	20	40	--	
7	A	11	Post	C-L-R	2	CH & SC	50	50	CT	33%	90	12	40	Crosscut	
	B	9	Post	L-C-R	1	CH & SC	50	50	CT	33%	90	12	40	Crosscut	Leave 2 left pillars for bleeder
	C	11	Post	L-C-R	1	CH & SC	50	50	CT	33%	90	12	40	Crosscut	Right hand miner
	D	11	MRS-2 & Posts	C-L-R	2	CH & SC	50	50	CT	33%	90	12	40	Crosscut	Mirror image applies
	E	11	MRS-2 & Posts	L-C-R	1	CH & SC	50	50	CT	33%	90	12	40	Crosscut	Right hand miner
	F	11	MRS-4	L-C-R	1	CH & SC	50	50	CT	39%	90	12	40	Crosscut	Mirror image applies when using left hand miner
	G	8	Post	C-L-R	2	CH & SC	50	50	CT	33%	90	12	36	Crosscut	Could also be C-R-L
	H	8	Post	C-L-R	2	CH & SC	30	50	SS	29%	90	12	39	Crosscut	Could also be C-R-L
	I	8	Post	L-C-R	1	CH & SC	50	50	CT	33%	90	12	40	Crosscut	Mirror image applies when using left hand miner
	J	6	Post	L-C-R	1	CH & SC	50	50	CT	33%	90	12	40	Crosscut	Leave 2 left pillars for bleeder
	K	11	MRS-2 & Posts	C-L-R	2	CH & SC	50	50	CT	33%	90	12	40	Crosscut	Could also be C-R-L
	L	11	MRS-2 & Posts	C-L-R	2	CH & SC	50	50	CT	39%	90	12	40	Crosscut	Could also be C-R-L
	M	11	MRS-2 & Posts	L-C-R	1	CH & SC	50	50	CT	33%	90	12	40	Crosscut	Mirror image applies when using left hand miner
	N	11	MRS-2 & Posts	L-C-R	1	CH & SC	50	50	CT	39%	90	12	40	Crosscut	Mirror image applies when using left hand miner
	O	7	MRS-4	L-C-R	1	CH & SC	40	40	CT	25%	90	12	40	Crosscut	
	P	11	MRS-4	L-C-R	1	CH & SC	50	50	CT	39%	90	12	40	Crosscut	Mirror Image applies when using left hand miner
	Q	7	MRS-4	L-C-R	1	CH & SC	40	40	CT	36%	90	12	40	Crosscut	

Kentucky Department for Natural Resources

Office of Mine Safety and Licensing

Approved Roof Control Plans (Retreat Mining)

Table 3

Study No.	Plan	No. of Entries	Method of Support	Sequence	No. of CM's	Coal Haulage	Pillar Dimension Width (ft.)	Pillar Dimension Length (ft.)	Retreat Type	% Remaining	Angle of Crosscuts	Pillar Split Width (ft.)	Rib Cut Depth (ft.)	Pillar Split	Comments
8	A	5	Post	L-R-C	1	CH	30-35	40	SS	15%	90	10	25	Crosscut	
	B	7	Post	L-R-C	1	CH	30-35	40	SS	15%	90	10	25	Crosscut	Center pillar is 35 feet wide
	C	6	Post	L-R-C	1	CH	30-35	40	SS	15%	90	10	25	Crosscut	
9	A	7	MRS-4	L-C-R	1	SC	50	65	CT	11%	90	12	30	Crosscut	Mirror image applies
	B	7	MRS-2 & Posts	L-C-R	1	SC	50	65	CT	14%	90	12	30	Crosscut	Mirror image applies
	C	7	Post	L-C-R	1	SC	60	50	CT	20%	90	12	30	Crosscut	Mirror image applies
	D	8	MRS-4	L-C-R	1	SC	60	70	CT	10%	90	12	30	Crosscut	Mirror image applies
	E	8	MRS-2 & Posts	L-C-R	1	SC	60	70	CT	12%	90	12	30	Crosscut	Mirror image applies
	F	8	Post	L-C-R	1	SC	60	70	CT	13%	90	12	30	Crosscut	Mirror image applies
	G	11	MRS-4	R-C-L	1	SC	40	40	SS	20%	90	12	30	Crosscut	Mirror image applies
	H	11	MRS-2 & Posts	R-C-L	1	SC	40	40	SS	20%	90	12	30	Crosscut	Mirror image applies
	I	11	Post	R-C-L	1	SC	40	40	SS	20%	90	12	30	Crosscut	Mirror image applies
10	A	5	MRS-2 & Posts	R-C-L	1	CH	67	72	CT	18%	70-90	14	45	Crosscut	
	B	5	MRS-2 & Posts	L-R-C	1	CH	67	72	CT	18%	70-90	14	45	Crosscut	
	C	7	Post	L-R-C	1	CH	67	72	CT	20%	70-90	14	45	Crosscut	
	D	7	MRS-2 & Posts	R-C-L	1	CH	43	62	SS	22%	70-90	14	45	Crosscut	
	E	7	Post	R-C-L	1	CH	35	55	SS	22%	70-90	14	45	Crosscut	Can also be L-C-R
	F	5	MRS-4	L-C-R	1	CH	68	76	CT	15%	70-90	14	45	Pushout	
	G	8	MRS-4	R-C-L	1	CH	50	60	CT	10%	90	12	30	Crosscut	
	H	8	MRS-2 & Posts	R-C-L	1	CH	50	60	CT	11%	90	12	30	Crosscut	
	I	8	Post	R-C-L	1	CH	50	60	CT	20%	90	12	30	Crosscut	
11	A	7	Post	L-R-C	1	CH	35	50	CT	28%	90	12	40	Crosscut	
	B	5	Post	L-R-C	1	CH	60	50	CT	16%	90	12	40	Crosscut	Center pillars 60x30
12	A	7	Post	L-C-R	1	SC	70	50	CT	27%	90	12	0	Crosscut	Bleeder pillar on both side of panel was not retreated; mirror image applies
	B	6	Post	L-C-R	1	SC	50	70	CT	15%	90	12	27	Crosscut	Alternate plan: barrier pillar not cut; mirror image applies
	C	7	Post	R-C-L	1	SC	70	50	CT	27%	90	12	0	Crosscut	
	D	10	Post	L-C-R	1	SC	40	40	CT	16%	90	11	32	Crosscut	
	E	10	Post	R-C-L	1	SC	40	40	CT	16%	90	11	32	Crosscut	
13	A	7	Post	L-C-R	1	SC	60	60	CT	32%	90	11	32	Crosscut	Bleeder pillar on both side of panel was not retreated
	B	7	Post	R-C-L	1	SC	60	60	CT	32%	90	11	32	Crosscut	Alternate plan: barrier pillar not cut
14	A	8	MRS-4	L-C-R	1	SC	60	70	CT	9%	90	<12	33	Crosscut	Mirror image applies; rib cut depth not supplied.
	B	8	MRS-2 & Posts	L-C-R	1	SC	60	70	CT	10%	90	<12	33	Crosscut	Mirror image applies; rib cut depth not supplied.
	C	8	Post	L-C-R	1	SC	60	70	CT	12%	90	<12	35	Crosscut	Mirror image applies; rib cut depth not supplied.
15	A	9	Post	C-L-R	2	RC/SC	40	60	SS	32%	90	12	40	Crosscut	Could also be C-R-L
	B	9	MRS-2 & Posts	C-L-R	2	SC	40	60	SS	32%	90	12	40	Crosscut	Could also be C-R-L
	C	9	MRS-2 & Posts	C-L-R	2	SC	40	60	SS	32%	90	12	40	Crosscut	Could also be C-R-L
	D	9	Post	C-L-R	2	SC	35	60	SS	32%	90	12	40	Crosscut	Could also be C-R-L
	E	9	Post	R-C-L	1	SC	40	60	SS	16%	90	12	40	Crosscut	Mirror image applies
16	A	10	Post	R-C-L	1	SC	40-50	40-50	CT	24%	90	11	32	Crosscut	Leave 1 partial block on right side
	B	10	Post	R-C-L	1	SC	40-50	40-50	CT	24%	90	11	32	Crosscut	
	C	5	Post	L-C-R	1	SC	28	50	SS	18%	90	11	32	Crosscut	Leave 2 left pillars for bleeder
	D	5	Post	L-C-R	1	SC	28	50	SS	18%	90	11	32	Crosscut	Supplied plan drawing was incomplete
	E	10	Post	L-C-R	1	SC	40-50	40-50	CT	16%	90	11	32	Crosscut	Supplied plan drawing was incomplete
	F	5	Post	L-C-R	1	SC	28	50	SS	18%	90	11	32	Crosscut	Supplied plan drawing was incomplete
	G	5	Post	L-C-R	1	SC	28	50	SS	18%	90	11	32	Crosscut	Supplied plan drawing was incomplete
17	A	5	Post	C-L-R	1	SC	35	36	SS	28%	60	12	44	Crosscut	
	B	7	Post	L-C-R	1	CH			SS	18%	60	12	52	Crosscut	Plan does not give pillar dimensions (Take only one cut out of 4th pillar)
	C	7	Post	L-C-R	1	CH			SS	18%	60	12	52	Crosscut	Plan does not give pillar dimensions (Take only one cut out of 3rd pillar)
18	A	9	Post	R-C-L	1	CH	40	40	SS	36%	90	<20	30	Crosscut	Rib cut depth not given, but measured on the map.
19	A	N/L	Post	L-C-R	1	SC	30	40	CT	15%	90	14-24	36	Crosscut	Plan does not give number of entries
	B	N/L	Post	R-C-L	1	SC	30	40	CT	15%	90	14-24	36	Crosscut	Plan does not give number of entries
	C	8	Post	L-C-R	1	SC	30	45	CT	8%	90	14-20	36	Crosscut	
20	A	3	Post	R-C-L	1	SC	40	50	CT	42%	90	12	N/L	--	

Kentucky Department for Natural Resources

Table 3

Office of Mine Safety and Licensing

Approved Roof Control Plans (Retreat Mining)

Table 3

Study No.	Plan	No. of Entries	Method of Support	Sequence	No. of CM's	Coal Haulage	Pillar Dimension Width (ft.)	Pillar Dimension Length (ft.)	Retreat Type	% Remaining	Angle of Crosscuts	Pillar Split Width (ft.)	Rib Cut Depth (ft.)	Pillar Split	Comments
21	A	3	Post	R-C-L	1	SC	40	40	SS	30%	90	24	36	Crosscut	
	B	3	Post	R-C-L	1	SC	40	40	CT	20%	90	24	36	Crosscut	
	C	7	Post	C-R-L	2	SC	40	40	CT	20%	90	24		Crosscut	Rib cut depth not given
	D	7	Post	C-L-R	2	SC	40	40	SS	15%	90	24		Crosscut	Rib cut depth not given
	E	4	Post	R-C-L	1	SC	30	50	SS	13%	90	12-14		Crosscut	Rib cut depth not given
	F	7	Post	R-C-L	2	SC	30	50	SS	13%	90	12-14	20	Crosscut	
	G	3	MRS-4	L-C-R	1	SC	40	50	SS	45%	90	12	30	--	
	H	3	MRS-3	L-C-R	1	SC	40	50	SS	45%	90	12	30	--	
	I	3	Post	L-C-R	1	SC	40	50	SS	45%	90	12	30	--	
	J	3	MRS-4	R-C-L	1	SC	40	50	SS	45%	90	12	30	--	
	K	3	MRS-3	R-C-L	1	SC	40	50	SS	45%	90	12	30	--	
	L	3	Post	R-C-L	1	SC	40	50	SS	45%	90	12	30	--	
	M	3	MRS-4 and Posts	R-C-L	1	SC	60	60	CT	27%	90	12	30	--	
22	A	3	Post	R-C-L	1	SC	40	40	SS	39%	90	24	30	Crosscut	
	B	5	Post	R-C-L	1	SC	40	40	CT	20%	90	24	30	Crosscut	
	C	3	Post	R-C-L	1	SC	40	50	SS	45%	90	12	35	Crosscut	
23	A	3	Post	R-C-L	1	SC	50	50	CT	29%	90	20	35	Crosscut	Right drive shuttle cars only
	B	3	Post	R-C-L	1	SC	50	50	CT	29%	90	20	35	Crosscut	
24	A	5	Post	R-C-L	1	SC	30	50	CT	13%	90	12	30	Crosscut	
25	A	3	Post	R-C-L	1	SC	50	50	CT	69%	90	16		--	Rib cut depth not given
26	A	3	Post	R-C-L	1	SC	40	40	CT	20%	90	24	35	Crosscut	
	B	3	Post	R-C-L	1	SC	40	40	SS	20%	90	24	35	Crosscut	
	C	3	Post	L-C-R	1	SC	40	40	CT	35%	90	20	35	Crosscut	
	D	5	Post	C-L-R	2	SC	40	50	CT	20%	90	20	35	Crosscut	
	E	5	Post	C-L-R	2	SC	40	50	CT	20%	90	20	35	Crosscut	
27	A	7	Post	C-R-L	2	SC	50	70	CT	27%	90	12	30	Crosscut	
	B	7	Post	C-L-R	2	SC	50	50	CT	26%	90	24		Crosscut	Rib cut depth not given
	C	7	Post	C-L-R	2	SC	50	50	CT	38%	90	12	25	--	
28	A	5	Post	C-L-R	2	SC	30	55	CT	33%	90	12	35	--	
	B	5	Post	L-C-R	1	SC	30	65	SS	34%	90	12	35	--	
	C	3	Post	L-C-R	1	SC	50	50	CT	25%	90	12	35	--	
29	A	3	Post	L-C-R	1	SC	40	40	SS	30%	90	24	35	Crosscut	Single sided until the last entry, then X-Mas Tree
	B	3	Post	R-C-L	1	SC	40	40	SS	30%	90	24	35	Crosscut	Single sided until the last entry, then X-Mas Tree
30	A	3	Post	R-C-L	1	SC	40	40	CT	26%	90	12-20		Crosscut	Rib cut depth not given
	B	5	Post	C-R-L	1	SC	40-60	60-100	CT	33%	90	12-20	N/A	Crosscut	
	C	6	Post	R-C-L	1	SC	56	70	SS	20%	90	12	40	Crosscut	
	D	6	Post	R-C-L	1	SC	56	70	CT	38%	90	12	N/L	--	
	E	6	Post	L-C-R	1	SC	56	70	CT	25%	90	12	N/L	--	
	F	5	Post	C-L-R	2	SC	56	70	CT	25%	90	12	N/l	--	
	G	6	MRS-4	R-C-L	1	SC	56	70	SS	18%	90	12	40	Crosscut	
	H	4	MRS-4	R-C-L	1	SC	70	80	CT	37%	90	12	≥20	--	
	I	4	MRS-4	L-C-R	1	SC	70	80	CT	37%	90	12	≥20	--	
	J	4	MRS-4	R-C-L	1	SC	90	90	SS	22%	90	12	N/L	--	

Kentucky Department for Natural Resources

Table 3

Office of Mine Safety and Licensing

Approved Roof Control Plans (Retreat Mining)

Table 3

Study No.	Plan	No. of Entries	Method of Support	Sequence	No. of CM's	Coal Haulage	Pillar Dimension Width (ft.)	Pillar Dimension Length (ft.)	Retreat Type	% Remaining	Angle of Crosscuts	Pillar Split Width (ft.)	Rib Cut Depth (ft.)	Pillar Split	Comments
31	A	3	Post	R-C-L	1	SC	36	40	CT	26%	90	20		Crosscut	Rib cut depth not given
	B	4	Post	C-R-L	1	SC	36	40	SS	33%	90	12-20	N/A	Crosscut	
	C	6	Post	R-C-L	1	SC	56	70	SS	20%	90	12	40	Crosscut	
	D	5	Post	R-C-L	1	SC	70	80	CT	38%	90	12	40	--	
	E	5	Post	L-C-R	1	SC	70	80	CT	38%	90	12	40	--	
	F	6	Post	R-C-L	1	SC	56	70	CT	25%	90	12	40	--	
	G	6	Post	L-C-R	1	SC	56	70	CT	25%	90	12	40	--	
	H	5	Post	C-R-L	2	SC	70	80	CT	25%	90	12	40	--	
	I	6	MRS-4	R-C-L	1	SC	56	70	SS	18%	90	12	40	Crosscut	
	J	4	MRS-4	R-C-L	1	SC	70	80	CT	37%	90	12-20	40	--	
	K	4	MRS-4	L-C-R	1	SC	70	80	CT	37%	90	12-20	40	--	
	L	4	MRS-4	R-C-L	1	SC	90	90	SS	22%	90	12	40	--	
	M	6	Post	R-C-L	1	SC	60	70	CT	13%	90	12	40	--	
32	A	5	Post	R-C-L	1	SC	30	50	SS	21%	90	12	30	Crosscut	
	B	3	Post	R-C-L	1	SC	40	40	SS	30%	90	24	35	Crosscut	
33	A	5	Post	R-C-L	1	SC	30	50	SS	15%	90	12	30	Crosscut	
	B	3	Post	R-C-L	1	SC	40	40	CT	29%	90	24	30	Crosscut	
	C	3	Post	R-C-L	1	SC	40	40	SS	30%	90	24	35	Crosscut	
34	A	4	MRS-4	L-C-R	1	CH	70	70	CT	23%	90	14	40	Crosscut	
	B	4	MRS-4	R-C-L	1	CH	70	70	CT	23%	90	14	40	Crosscut	

Legend	
CH =	Continuous Haulage
CM =	Continuous Miner
CT =	Christmas Tree
MRS =	Mobile Roof Support
N/A =	Not Applicable
N/L =	Not Listed
RC =	Ram Car
SC =	Shuttle Car
SS =	Single Sided

Kentucky Department for Natural Resources

Office of Mine Safety and Licensing

ARMPS

Table 4

Study No.	Seam	Entry Width (ft.)	Entry Height (in.)	Max Depth Cover Reported (ft.)	Locations on the Map	Depth Cover Measured (ft.)	Cross Cut Spacing (ft.)	Cross Cut Angle (deg)	No. of Entries	Entry Spacing CC (ft.)	SF for Loading Condition 1	SF for Loading Condition 2	SF for Loading Condition 3	SF for Loading Condition 4	Comments
1	Buckeye Spring	20	32	1,100	Location 1	1,110	70	90	7	70.0	2.62	1.78			
					Location 2	560	70	90	9	70.0	5.20	3.23			
					Location 3	300	90	90	5	70.0	11.95	8.32			
					Location 4	460	70	90	9	70.0	6.33	3.99			
					Location 5	940	70	90	8	70.0	3.10	2.07	1.18	1.75	
					Location 6	840	70	90	8	70.0	3.47	2.21	2.07	1.95	
					Location 7	1,060	70	90	8	70.0	2.75	1.78	1.64	1.52	
2	Hazard #4	20	48	1,200	Location 1	843	50	60	5	45.0	0.83	0.67	0.52	0.42	General plan shown in the report
					Location 1	843	60	60	5	55.0	1.42	1.09	0.89	0.75	General plan, dimensions measured in the map
					Location 2	478	60	60	5	55.0	2.50	1.83	1.61	1.43	General plan, dimensions measured in the map
					Location 3	483	60	60	5	55.0	2.47	1.81	1.59	1.42	General plan, dimensions measured in the map
3	Hazard #4	20	48	1,150	Location 1	380	60	90	5	60.0	3.97	2.72	2.56		A panel close to the portal
		20	48	1,150	Location 2	726	60	60	5	52.5	1.57	1.20	0.96	0.80	Within a panel in the north
4	Hazard #4	20	48	500+	Location 1	743	60	90	7	60.0	1.83	1.26			A single retreat mining panel in South, between two sealed mining district
					Location 2	696	60	90	9	60.0	2.17	1.37			A super section close to Lick Fork Creek
5	Hazard #8	20	48	300	Location 1	345	55	60	5	50.0	2.73	2.00			Development, 2 rows of pillar retreated, 2 rows of pillars were kept as bleeder pillar; all assumed retreated for conservative analysis
		20	48	300	Location 2	357	60	90	7	60.0	4.22	2.84			Regular panel
6	Hazard #4	20	48	700	Location 1	450	60	90	10	60.0	3.23	2.15			10 entry system but analyzed as if 9 entry system due to ARMPS limitation
					Location 2	390	60	90	10	60.0	3.87	2.50			10 entry system but analyzed as if 9 entry system due to ARMPS limitation
7	Hazard #4	20	84	1,100	Location 1	380	70	90	7	60.0	4.61	3.09	2.95		7 entry system along the right side of the development entries
					Location 2	840	60	90	5	60.0	1.79	1.53	1.17	1.03	5 entry system in regular panel
					Location 3	380	70	90	8	70.0	5.50	3.63	3.48		8 entry super section
					Location 4	380	70	90	8	50.0	3.50	2.40	2.26		
8	Harlan	20	31.2	1,300	Location 1	1,120	60	90	5	52.5	1.64	1.64	1.40		No. 3 South Main
					Location 2	900	60	90	7	51.7	1.99	1.43	1.36		No. 2 South Main
					Location 3	945	60	90	6	52.0	1.90	1.42	1.23	1.08	
					Location 4	1,180	60	90	7	52.5	1.56	1.14			
					Location 5	1,085	61	90	7	51.7	1.68	1.23			
9	Pardee	20	60	800	Location 1	720	80	90	7	80.0	3.10	1.97	1.90	1.82	
					Location 2	790	90	90	6	80.0	3.11	2.07	1.71		
					Location 3	460	90	90	6	80.0	5.34	3.51	3.34	3.18	
					Location 4	760	75	90	7	80.0	2.76	1.76	1.65		
					Location 5	300	90	90	6	80.0	8.20	5.51	5.31	5.21	
					Location 6	880	90	90	6	80.0	2.79	1.88	1.72	1.59	

Kentucky Department for Natural Resources

Office of Mine Safety and Licensing

ARMPS

Table 4

Study No.	Seam	Entry Width (ft.)	Entry Height (in.)	Max Depth Cover Reported (ft.)	Locations on the Map	Depth Cover Measured (ft.)	Cross Cut Spacing (ft.)	Cross Cut Angle (deg)	No. of Entries	Entry Spacing CC (ft.)	SF for Loading Condition 1	SF for Loading Condition 2	SF for Loading Condition 3	SF for Loading Condition 4	Comments
10	Kellioka	20	48	2,150	Location 1	600	80	80	7	55.0	2.81	1.92	1.74	1.59	
					Location 2	400	80	80	7	55.0	4.22	2.86			
					Location 3	500	80	80	7	55.0	3.37	2.29	2.11		
					Location 4	400	80	80	11	55.0	4.22	2.76	2.63		
					Location 5	600	85	80	7	55.0	2.91	1.99	1.85	1.65	
					Location 6	900	90	80	5	90.0	3.71	2.56	2.33		
					Location 7	800	80	80	7	55.0	2.11	1.47	1.31	1.19	
					Location 8	1,900	95	80	5	75.0	1.52	1.18	0.99	0.85	
					Location 9	1,000	80	80	7	55.0	1.69	1.20	1.10		
					Location 10	1,600	95	80	5	82.5	2.00	1.50	1.30	1.15	
					Location 11	1,900	80	80	5	80.0	1.42	1.09	0.92	0.79	
					Location 12	1,000	80	80	5	90.0	2.97	2.07	1.90	1.75	
11	Upper Harlan	20	38	1,400	Location 1	428	70	90	5	70.0	6.04	4.20			
					Location 2	182	70	90	5	80.0	16.04	11.45			
					Location 3	485	70	90	5	75.0	5.70	3.93	3.79	3.67	
					Location 4	800	70	90	5	75.0	3.45	2.47	2.13	1.87	
					Location 5	955	70	90	5	65.0	2.49	1.87	1.66	1.50	
					Location 6	635	70	90	5	65.0	3.75	2.71	2.68	2.66	
12	High Splint	20	42	845	Location 1	560	87.5	90	8	71.4	4.16	2.62			Two side pillar rows were not retreated; result is conservative
					Location 2	415	60	90	8	60.0	2.41	1.58			Two center pillar rows were retreated; part of super section
13	Wallins Creek	20	48	1,350	Location 1	370	80	90	5	80.0	7.35	5.00			
					Location 2	475	80	90	8	80.0	5.72	3.59			
					Location 3	788	80	90	6	80.0	3.45	2.30			
14	Harlan	20	45	1,700	Location 1	880	90	90	8	80.0	3.61	2.23	2.10		
					Location 2	1,165	120	90	5	90.0	3.49	2.50	2.20	1.96	
					Location 3	900	90	90	5	80.0	3.53	2.51	2.25		
					Location 4	1,700	90	90	6	80.0	1.87	1.34	1.12		
					Location 5	1,787	110	90	6	100.0	2.56	1.75	1.46		Fatality site
					Location 6	2,068	110	90	6	100.0	2.21	1.53			
					Location 7	2,070	110	90	5	100.0	2.21	1.62			
15	Amburgy	20	48	450	Location 1	701	80	90	9	55.0	2.42				A super section along the mains close to portal
					Location 2	501	80	90	9	55.0	3.39	2.18	2.07	1.97	
					Location 3	230	80	90	9	55.0	7.38	5.06	4.94	4.82	
16	No. 5A	20	45 - 90 @ 48	550	Location 1	441	70	90	6	70.0	4.75	3.18	3.00	2.83	
					Location 2	404	70	90	7	50.0	3.29	2.26			
17	Elkhorn #4	20	36	1,000	Location 1	530	60	60	5	55.0	2.88	2.13	1.88	1.68	1 west 5 left
				1,000	Location 2	375	75	60	7	50.0	4.43	3.04	2.83	2.65	1 west 2 left
				1,000	Location 3	445	60	60	5	55.0	3.43	2.50			3 west 1 right; two rows of pillars were retreated
18	Hazard #4	20	50	NA	Location 1	370	60	90	8	60.0	3.91	2.58	2.58		
					Location 2	450	60	90	8	60.0	3.21	2.10	2.09	2.07	Barrier pillars were not retreated
					Location 3	437	60	90	9	60.0	3.31	2.13	1.82	1.60	Super section
					Location 4	414	60	90	8	60.0	3.49	2.29	2.21	2.21	

Kentucky Department for Natural Resources

Office of Mine Safety and Licensing

ARMPS

Table 4

Study No.	Seam	Entry Width (ft.)	Entry Height (in.)	Max Depth Cover Reported (ft.)	Locations on the Map	Depth Cover Measured (ft.)	Cross Cut Spacing (ft.)	Cross Cut Angle (deg)	No. of Entries	Entry Spacing CC (ft.)	SF for Loading Condition 1	SF for Loading Condition 2	SF for Loading Condition 3	SF for Loading Condition 4	Comments
19	Pond Creek	20	36 - 89 @ 62.5	1,250	Location 1	625	60	90	7	60.0	1.94	1.30			Part of super section
					Location 2	1,022	60	90	7	55.0	1.07	0.76	0.49	0.36	
					Location 4	850	60	90	7	50.0	1.12	0.80	0.53	0.39	
					Location 5	800	60	90	9	60.0	1.52	0.97	0.73		
					Location 6	832	60	90	7	53.3	1.26	0.89	0.60	0.45	
					Location 7	1,030	60	90	9	60.0	1.18	0.76	0.53		
					Location 8	702	60	90	7	50.0	1.36	0.96			
					Location 9	621	60	90	7	50.0	1.53	1.07	0.78		
					Location 10	482	60	90	9	50.0	1.98	1.29	1.14		
					Location 14	320	50	90	8	70.0	3.36	2.21	2.10	1.99	
					Location 15	540	70	90	7	70.0	3.10	2.01			
					Location 16	506	60	90	10	50.0	1.88	1.23			
					Location 17	910	60	90	10	50.0	1.05	0.70	0.48	0.37	
					Location 18	520	60	90	9	50.0	1.83	1.20			
					Location 19	620	60	90	9	50.0	1.54	1.01			
					Location 20	510	70	90	7	70.0	3.28	2.13			
20	Elkhorn #2	20	40	500	Location 1	465	70	90	7	60.0	4.96	3.31			Four rows retreated and two rows were left as bleeder pillars
21	Lower Elkhorn	20	50	650	Location 1	445	80	90	8	60.0	4.35	2.84	2.73	2.63	No pillared area shown in the map
22	Elkhorn #3	20	48 - 60 @ 54	450	Location 1	280	75.0	90	7	60.0	4.04	2.70	2.22		Development entries, 4 rows of pillars were retreated
					Location 2	220	60	90	7	60.0	3.30	2.20	2.18	2.15	
23	Lower Alma	20	40	375	Location 1	230	70	90	9	70.0	10.73	7.29			
					Location 2	195	70	90	7	70.0	12.65	8.86	8.68		
					Location 3	400	70	90	8	70.0	6.17	3.99	3.87	3.39	
					Location 4	210	70	90	7	70.0	11.75	8.17			
					Location 5	423	70	90	7	70.0	5.83	3.81			
24	Clintwood	20	36	400	Location 1	610	61.5	90	7	50.0	2.52	1.76	1.65	1.55	
					Location 2	315	70.0	90	11	50.0	5.40	3.62			
					Location 3	420	70.0	90	7	50.0	4.05	2.78	2.67		
					Location 4	315	70.0	90	8	50.0	5.40	3.66	3.57	3.49	
					Location 5	485	70.0	90	9	50.0	3.51	2.30	2.23	2.17	
					Location 6	620	70.0	90	8	50.0	2.74	1.85	1.76	1.68	
					Location 7	600	70.0	90	7	50.0	2.83	1.98	1.86	1.75	
25	Elkhorn #1	20	79	750	Location 1	490	70	90	7	70.0	2.80	1.82	1.76	1.71	
					Location 2	705	70	90	7	70.0	1.95	1.27	1.20	1.13	
					Location 3	365	70	90	8	70.0	3.27	2.45	2.51	2.38	
					Location 4	752	70	90	7	70.0	1.83	1.20	1.01		
					Location 5	415	70	90	9	70.0	3.31	2.10	2.05		
					Location 6	440	70	90	8	70.0	3.12	2.00	1.96		
26	Elkhorn #3	20	95	500	Location 1	320	70	90	9	70.0	3.69	2.41	2.36		
					Location 2	305	70	90	9	60.0	3.27	2.17			
					Location 3	630	60	90	9	60.0	1.38	0.87	0.78		
					Location 4	440	60	90	8	60.0	1.97	1.26	1.23	1.12	
					Location 5	535	60	90	7	60.0	1.62	1.08	1.06	1.04	
					Location 6	445	60	90	7	60.0	1.95	1.30	1.24	1.19	
					Location 7	450	70	90	9	60.0	2.22	1.42	1.37		

Kentucky Department for Natural Resources

Office of Mine Safety and Licensing

ARMPS

Table 4

Study No.	Seam	Entry Width (ft.)	Entry Height (in.)	Max Depth Cover Reported (ft.)	Locations on the Map	Depth Cover Measured (ft.)	Cross Cut Spacing (ft.)	Cross Cut Angle (deg)	No. of Entries	Entry Spacing CC (ft.)	SF for Loading Condition 1	SF for Loading Condition 2	SF for Loading Condition 3	SF for Loading Condition 4	Comments
27	Elkhorn #2	20	55	600	Location 1	365	70	90	9	70.0	5.09	3.28			1st southwest panel
					Location 2	390	70	90	9	70.0	4.77	3.05			3rd northwest mains
					Location 3	395	70	90	7	70.0	4.70	3.09	2.63		3rd northwest panel
					Location 4	945	70	90	7	70.0	1.97	1.31	1.21		1st northwest panel
					Location 5	775	70	90	9	70.0	2.40	1.48	1.16	1.14	
					Location 6	770	70	90	9	70.0	2.41	1.49	1.44		
					Location 7	590	90	90	9	70.0	3.85	2.38	2.32		
28	Elkhorn #2	20	32	500	Location 1	360	90	90	9	60.0	8.28	5.40			
					Location 2	578	90	90	9	60.0	5.16	3.27	3.20	3.07	
					Location 3	185	85	90	7	60.0	15.59	11.07	10.86		
					Location 4	476	85	90	9	60.0	6.06	3.87	3.79	3.72	
					Location 5	486	85	90	9	60.0	5.93	3.79	3.71	3.63	
29	Elkhorn #3	20	46	800	Location 1	565	60	90	9	60.0	2.77	1.76	1.74	1.67	
					Location 2	475	60	90	9	60.0	3.29	2.10	1.89	1.71	
					Location 3	585	60	90	8	60.0	2.67	1.74	1.71		
					Location 4	350	60	90	9	60.0	4.47	2.92			
					Location 5	390	60	90	9	60.0	4.01	2.60	2.55		
30	Pond Creek	20	60	1,150	Location 1	700	100	90	7	70.0	3.21	2.03	1.93		
					Location 2	800	100	90	7	70.0	2.81	1.78	1.66	1.44	
					Location 3	500	80	90	7	70.0	3.89	2.47	2.39		
					Location 4	500	70	90	11	70.0	3.46	2.16	2.10		
31	Cedar Grove	20	48	1,050	Location 1	350	85	90	9	55.0	5.02	3.31	3.18	3.06	
					Location 2	670	85	90	8	55.0	2.62	1.75	1.48		
					Location 3	590	60	90	7	60.0	2.56	1.71			
					Location 4	560	70	90	7	55.0	2.77	1.89	1.77	1.67	
32	Elkhorn #2	20	36	250	Location 1	720	60	90	7	60.0	2.69	1.82			
					Location 2	825	50	90	9	50.0	1.48	0.99			
					Location 3	420	60	90	7	60.0	4.61	3.07	3.06		
					Location 4	40	70	90	7	50.0	42.51	35.02			
					Location 5	420	70	90	7	50.0	4.05	2.78			
					Location 6	625	80	90	7	50.0	2.96	2.07	2.03		
33	Clintwood	20	36	400	Location 1	270	60	90	9	60.0	7.16	4.82	4.68		
					Location 2	470	60	90	6	80.0	5.31	3.48	3.24	3.03	
					Location 3	460	70	90	8	50.0	3.70	2.48	2.37	2.27	
					Location 4	450	60	90	9	60.0	4.30	2.76	2.52	2.44	
					Location 5	240	70	90	9	50.0	7.09	4.87	4.75		
					Location 6	260	60	90	7	60.0	7.44	5.11	4.84		
34	Darby	20	135.6	2000	Location 1	1080	110	90	5	110	1.74				
					Location 2	1500	95	90	4	100	1.05	0.79	0.71		
					Location 3	640	95	90	7	95	2.36	1.45	1.41		
					Location 4	880	95	90	5	95	1.72	1.17	1.09		
					Location 5	1530	115	90	5	115	1.31	0.9	0.85		
					Location 6	1600	115	90	5	115	1.25				
					Location 7	980	95	90	5	95	1.54	1.06	1.01		

Note:

Loading condition 1: development load only

Loading condition 2: one active retreat section

Loading condition 3: one active retreat section + one side gob

Loading condition 4: one active retreat section + two side gobs

CC = Cross Cut

SF = Safety Factor

Kentucky Department for Natural Resources
Office of Mine Safety and Licensing
Reportable Roof Falls
Table 5

	2005			2004			2003		
Study No.	**Date**	**Source**	**Injury**	**Date**	**Source**	**Injury**	**Date**	**Source**	**Injury**
1	01/13/05	MSHA	Reportable	06/16/04	MSHA	Fatality	05/07/03	KYOMSL	Reportable
	01/31/05	MSHA	None						
	08/17/05	MSHA	None						
2	02/17/05	KYOMSL	Reportable	04/08/04	KYOMSL	Reportable	12/08/03	KYOMSL	Reportable
				05/22/04	KYOMSL	Reportable			
				07/15/04	KYOMSL	Reportable			
3	01/02/05	MSHA	None	03/01/04	KYOMSL	Reportable	03/20/03	KYOMSL	Reportable
	01/14/05	MSHA	None	04/23/04	MSHA	None	04/15/03	MSHA	None
	01/20/05	MSHA	None	05/11/04	MSHA	Reportable	05/05/03	KYOMSL	Reportable
	03/14/05	MSHA	None	05/13/04	MSHA	None	06/19/03	MSHA	None
	08/19/05	MSHA	Reportable	07/19/04	KYOMSL	Reportable	12/31/03	KYOMSL	Reportable
	08/23/05	MSHA	None	07/23/04	KYOMSL	Reportable			
				08/02/04	MSHA	None			
				08/30/04	MSHA	None			
				10/08/04	KYOMSL	Reportable			
				10/13/04	KYOMSL	Reportable			
				10/18/04	MSHA	None			
4	03/11/05	KYOMSL	Reportable						
7	03/30/05	MSHA	None	01/07/04	MSHA	None	01/16/03	KYOMSL	Reportable
				03/12/04	MSHA	None	08/12/03	MSHA	None
				03/26/04	KYOMSL	Reportable	11/14/03	MSHA	None
				04/05/04	MSHA	None			
				04/09/04	MSHA	None			
				04/27/04	KYOMSL	Reportable			
				04/30/04	MSHA	None			
				05/03/04	MSHA	None			
				06/01/04	MSHA	None			
				06/07/04	MSHA	None			
				06/21/04	MSHA	None			
				07/06/04	MSHA	None			
				07/20/04	KYOMSL	Reportable			
8							08/21/03	MSHA	Reportable
9	04/26/05	MSHA	None	05/26/04	MSHA	Reportable	05/30/03	MSHA	None
	09/24/05	MSHA	None	09/30/04	MSHA	Minor	10/10/03	MSHA	Reportable
				11/10/04	KYOMSL	Reportable			
10	02/04/05	MSHA	None	01/02/04	MSHA	None	01/11/03	MSHA	None
	02/13/05	MSHA	None	01/11/04	MSHA	None	01/27/03	MSHA	None
	02/22/05	MSHA	None	01/19/04	MSHA	None	02/04/03	MSHA	None
	07/13/05	KYOMSL	Reportable	02/15/04	MSHA	None	03/24/03	MSHA	None
	07/15/05	MSHA	None	03/09/04	MSHA	None	05/02/03	MSHA	Reportable
	08/29/05	MSHA	None	04/14/04	MSHA	None	05/15/03	MSHA	None
				04/23/04	KYOMSL	Reportable	05/16/03	MSHA	None
				05/03/04	MSHA	None	05/22/03	MSHA	None
				06/07/04	MSHA	None	06/26/03	MSHA	None
				07/01/04	MSHA	None	08/18/03	MSHA	None
				08/08/04	MSHA	None	09/02/03	MSHA	None
				08/19/04	MSHA	None	09/16/03	MSHA	Minor
				09/08/04	MSHA	None	10/03/03	MSHA	Reportable
				09/08/04	MSHA	None	10/30/03	MSHA	None
				09/08/04	MSHA	None	11/04/03	MSHA	None
				09/23/04	MSHA	None	12/29/03	MSHA	None
				10/05/04	MSHA	None			
11	05/17/05	MSHA	None	02/26/04	KYOMSL	Reportable	07/10/03	MSHA	None
				05/21/04	MSHA	None	11/03/03	MSHA	None

Kentucky Department for Natural Resources
Office of Mine Safety and Licensing
Reportable Roof Falls
Table 5

	2005			2004			2003		
Study No.	**Date**	**Source**	**Injury**	**Date**	**Source**	**Injury**	**Date**	**Source**	**Injury**
14	04/12/05	MSHA	Reportable	11/10/04	MSHA	Reportable			
	08/03/05	KYOMSL	Fatality						
	08/03/05	KYOMSL	Fatality						
	08/04/05	MSHA	None						
	08/04/05	MSHA	Reportable						
15	03/08/05	MSHA	None	05/06/04	MSHA	None	07/30/03	MSHA	None
	03/22/05	MSHA	None	05/12/04	MSHA	None			
	05/21/05	MSHA	None	05/19/04	MSHA	None			
				05/20/04	MSHA	None			
				06/15/04	MSHA	None			
				06/23/04	MSHA	None			
				07/01/04	MSHA	None			
				07/20/04	MSHA	None			
				07/27/04	MSHA	None			
				08/29/04	MSHA	None			
17	01/09/05	MSHA	None	03/19/04	MSHA	None	07/03/03	MSHA	None
	02/25/05	MSHA	None	03/26/04	MSHA	None	09/11/03	KYOMSL	Reportable
	06/24/05	KYOMSL	Reportable	06/15/04	MSHA	None	12/15/03	MSHA	Minor
				07/06/04	MSHA	Minor			
				12/03/04	MSHA	None			
				12/10/04	MSHA	Reportable			
18				08/02/04	MSHA	Fatality			
19	01/04/05	KYOMSL	Reportable	01/26/04	KYOMSL	Reportable	02/07/03	KYOMSL	Reportable
	01/07/05	KYOMSL	Reportable	03/02/04	MSHA	None	02/24/03	MSHA	None
	01/28/05	MSHA	None	06/01/04	MSHA	None	05/22/03	KYOMSL	Reportable
	05/11/05	MSHA	None	07/30/04	MSHA	None	06/05/03	KYOMSL	Reportable
	06/01/05	MSHA	None	09/27/04	MSHA	None	08/13/03	MSHA	None
	06/07/05	MSHA	None	12/08/04	MSHA	None	10/31/03	MSHA	Minor
	07/27/05	KYOMSL	Reportable						
	08/02/05	MSHA	Minor						
	09/07/05	MSHA	None						
	09/07/05	MSHA	Minor						
	09/10/05	MSHA	None						
	09/13/05	MSHA	Reportable						
20							09/28/03	MSHA	None
21	06/19/05	MSHA	None	05/03/04	MSHA	Reportable	08/21/03	MSHA	None
	07/27/05	MSHA	None	05/04/04	KYOMSL	Reportable			
	08/11/05	MSHA	None						
22	02/28/05	KYOMSL	Reportable	01/01/04	MSHA	None	01/13/03	KYOMSL	Reportable
				02/08/04	MSHA	None	02/18/03	MSHA	None
				08/30/04	MSHA	None	05/05/03	MSHA	None
				09/23/04	MSHA	None	06/10/03	MSHA	None
							07/06/03	MSHA	None
							08/19/03	MSHA	None
							10/23/03	MSHA	None
23	02/01/05	KYOMSL	Reportable				01/09/03	KYOMSL	Reportable
							04/22/03	KYOMSL	Reportable
							06/10/03	KYOMSL	Reportable
							06/11/03	MSHA	Reportable
							08/27/03	KYOMSL	Reportable
							09/10/03	MSHA	None
24				01/02/04	KYOMSL	Reportable			
25	01/18/05	MSHA	Reportable	04/19/04	MSHA	Reportable			
	06/13/05	MSHA	None						

Kentucky Department for Natural Resources
Office of Mine Safety and Licensing
Reportable Roof Falls
Table 5

	2005			2004			2003		
Study No.	**Date**	**Source**	**Injury**	**Date**	**Source**	**Injury**	**Date**	**Source**	**Injury**
26				05/13/04	KYOMSL	Reportable			
27	02/16/05	MSHA	Reportable						
	04/13/05	MSHA	Reportable						
28				11/15/04	MSHA	None	09/22/03	MSHA	None
29	01/31/05	MSHA	None	01/06/04	MSHA	None	01/10/03	MSHA	None
	03/25/05	MSHA	None	05/21/04	MSHA	None	01/28/03	MSHA	None
	05/24/05	MSHA	None	08/16/04	MSHA	None	02/26/03	KYOMSL	Reportable
	06/12/05	MSHA	None				08/13/03	KYOMSL	Reportable
	07/08/05	MSHA	None						
	07/26/05	MSHA	Reportable						
	08/02/05	MSHA	Minor						
	08/31/05	MSHA	Minor						
	09/20/05	MSHA	None						
	09/26/05	MSHA	None						
30	02/07/05	KYOMSL	Reportable	03/04/04	MSHA	None	01/04/03	MSHA	None
	02/26/05	MSHA	Minor	04/21/04	MSHA	Reportable	01/10/03	KYOMSL	Reportable
	04/08/05	KYOMSL	Reportable	05/11/04	KYOMSL	Reportable	02/20/03	MSHA	None
				08/12/04	KYOMSL	Reportable	03/02/03	MSHA	None
				10/26/04	KYOMSL	Reportable	03/04/03	MSHA	None
				10/30/04	KYOMSL	Reportable	04/26/03	KYOMSL	Reportable
							05/12/03	MSHA	Reportable
							05/16/03	KYOMSL	Reportable
							08/12/03	KYOMSL	Reportable
							09/02/03	KYOMSL	Reportable
							10/24/03	MSHA	None
31	01/02/05	MSHA	None	01/27/04	MSHA	None	01/07/03	KYOMSL	Reportable
	03/11/05	MSHA	None	02/26/04	MSHA	None	03/23/03	MSHA	Minor
	05/01/05	MSHA	None	03/02/04	MSHA	None	03/29/03	KYOMSL	Reportable
	05/31/05	MSHA	None	05/15/04	MSHA	None	04/09/03	MSHA	None
	08/06/05	MSHA	None	07/08/04	MSHA	Minor	04/21/03	MSHA	None
	08/24/05	MSHA	Minor	08/19/04	KYOMSL	Reportable	04/23/03	MSHA	None
	09/03/05	MSHA	None	09/12/04	MSHA	None	05/11/03	MSHA	None
				09/15/04	MSHA	None	08/12/03	MSHA	None
							08/18/03	MSHA	None
							08/25/03	KYOMSL	Reportable
							10/15/03	MSHA	None

Study Number not noted above indicates no report of roof falls

State	Date	Source	Injury
West Virginia	02/20/02	MSHA - Not in Study	Fatality
West Virginia	12/27/02	MSHA - Not in Study	Fatality
Western Kentucky	08/20/03	KYOMSL - Not in Study	Fatality
Virginia	10/24/03	MSHA - Not in Study	Fatality
Kentucky	06/17/04	KYOMSL - Not in Study	Fatality
Kentucky	07/30/04	KYOMSL - Not in Study	Reportable

Kentucky Department for Natural Resources

Table 6

Office of Mine Safety and Licensing

Summary of Accident and Injury Statistics Due

Table 6

	2005							2004							2003						
Study No.	**Total Accidents**	**Total Injuries**	**NFDL Injuries**	**Roof Falls**	**Roof Fall Injuries**	**Serious Roof Fall Injuries**	**Roof Fall Fatals**	**Total Accidents**	**Total Injuries**	**NFDL Injuries**	**Roof Falls**	**Roof Fall Injuries**	**Serious Roof Fall Injuries**	**Roof Fall Fatals**	**Total Accidents**	**Total Injuries**	**NFDL Injuries**	**Roof Falls**	**Roof Fall Injuries**	**Serious Roof Fall Injuries**	**Roof Fall Fatals**
1	7	5	4	3	1	1		9	9	6	1	1	1	1	9	9	8	1	1	1	
2	22	22	13	1	1	1		26	26	19	3	3	3		24	24	17	1	1	1	
3	31	26	22	6	1	1		32	28	25	10	6	6		22	20	12	5	3	3	
4	1	1	1	1	1	1		1	1	0							0				
5	5	5	3												4	4	4				
6	1	1	1					5	5	4							0				
7	8	7	2	1				19	9	5	13	3	3		9	7	4	3	1	1	
8	1	1	1					1	1	1					1	1	1	1	1	1	
9	6	4	4	2				8	8	6	3	3	2		8	7	6	2	1	1	
10	11	6	4	6	1	1		25	9	5	17	1	1		24	11	6	16	3	2	
11	3	2	1	1				4	3	3	2	1	1		17	15	15	2			
12	1	1	1												1	1	0				
13	1	1	0														0				
14	14	13	9	5	4	4	2	11	11	11	1	1	1		8	8	5				
15	7	4	2	3				14	4	3	10				6	5	3	1			
16	0	0	0												4	4	4				
17	11	9	7	3	1	1		14	9	5	7	2	1		13	12	3	3	2	1	
18	0	0	0					2	2	1	1	1	1	1			0				
19	31	25	14	12	6	4		16	11	5	6	1	1		29	27	15	6	4	3	
20	2	2	1					2	2	1					1	0	0	1			
21	3	0	0	3				3	3	3	2	2	2		3	2	2	1			
22	5	5	1	1	1	1		7	3	0	4				8	2	3	7	1	1	
23	4	4	4	1	1	1		4	4	4					15	14	10	6	5	5	
24	1	1	1					2	2	1	1	1	1		1	1	1				
25	5	4	3	2	1	1		4	4	4	1	1	1		3	3	3				
26	3	3	3					2	2	1	1	1	1				0				
27	4	4	4	2	2	2											0				
28	4	4	3	0	0	0		2	1	1	1				4	4	3	1	1		
29	10	3	1	10	3	1		10	7	5	3				7	5	3	4	2	2	
30	12	12	9	3	3	2		19	18	10	6	5	5		23	18	10	11	6	6	
31	14	8	2	7	1			32	26	8	8	2	1		26	19	9	11	4	3	
32															0	0	0				
33	1	1	1					1	1	1					0	0	0				
34	6	6	3					3	3	1					0	0	0				
	235	**190**	**125**	**73**	**28**	**22**	**2**	**278**	**212**	**139**	**101**	**35**	**32**	**2**	**270**	**223**	**147**	**83**	**36**	**31**	**0**
District																					
Barboursville	75	67	46	12	4	4	0	92	78	59	27	13	13	1	68	64	45	10	6	6	0
Harlan	43	34	23	14	5	5	2	52	35	27	23	6	5	0	59	43	33	21	5	4	0
Hazard	18	13	9	6	1	1	0	30	15	9	18	3	2	1	23	21	10	4	2	1	0
Martin	31	25	14	12	6	4	0	16	11	5	6	1	1	0	29	27	15	6	4	3	0
Pikeville	68	51	33	29	12	8	0	88	73	39	27	12	11	0	91	68	44	42	19	17	0
Total	**235**	**190**	**125**	**73**	**28**	**22**	**2**	**278**	**212**	**139**	**101**	**35**	**32**	**2**	**270**	**223**	**147**	**83**	**36**	**31**	**0**

NOTES

Total Accidents All accidents reported to MSHA and listed on www.MSHA.gov.
Total Injuries Number of accidents that resulted in physical injury requiring medical attention.
NFDL Injuries Total number of injuries with days lost from work.
Roof Falls Total number of reportable roof falls listed as Accidents by MSHA.
Roof Fall Injuries Total number of injuries resulting from a fall of roof. Not all roof falls resulted in an injury.
Serious Roof Fall Injuries Total number of roof falls that resulted in injuries with days lost from work.
Roof Fall Fatals Total number of fatalities resulting from roof falls.

Kentucky Department for Natural Resources

Table 7

Office of Mine Safety and Licensing

Accident Summary

Table 7

	YTD 3rd Quarter 2005									2004									2003									
Study No.	Fatals	NFDL Injuries	Man-hours	Tons	FIR	NFDL-IR	Roof Fall Injuries	RFI-IR	Manpower	Fatals	NFDL Injuries	Man-hours	Tons	FIR	NFDL-IR	Roof Fall Injuries	RFI-IR	Manpower	Fatals	NFDL Injuries	Man-hours	Tons	FIR	NFDL-IR	Roof Fall Injuries	RFI-IR	Manpower	*Footnote No.*
1	0	4	85,539	170,476	0.000	9.35	1	2.338	44	1	6	116,556	402,789	1.716	10.30	1	1.716	49	0	8	110,900	484,547	0.000	14.43	1	1.803	44	*6*
2	0	13	201,085	760,946	0.000	12.93	1	0.995	97	0	19	235,055	897,801	0.000	16.17	3	2.553	92	1	17	217,189	1,014,576	0.921	15.65	1	0.92	83	*5*
3	0	22	203,702	646,338	0.000	21.60	1	1	97	0	25	257,121	944,444	0.000	19.45	6	4.667	103	0	12	239,725	1,015,164	0.000	10.01	3	2.50	90	
4	0	1	75,393	278,213	0.000	2.65	1	2.65	42	0	0	31,897	108,763	0.000	0.00	0	0.000	36	0	0	0	0	0.000	0.00	0	0.00	0	
5	0	3	44,972	119,429	0.000	13.34	0	0.00	45	0	0	7,400	2,071	0.000	0.00	0	0.000	17	0	4	83,974	148,701	0.000	9.53	0	0.00	40	*4*
6	0	1	90,164	430,715	0.000	2.22	0	0.00	56	0	4	33,288	44,204	0.000	24.03	0	0.000	33	0	0	0	0	0.000	0.00	0	0.00	0	
7	0	2	140,580	369,033	0.000	2.85	0	0.00	67	0	5	158,389	539,154	0.000	6.31	3	3.788	59	0	4	146,889	766,673	0.000	5.45	1	1.36	54	
8	0	1	42,357	98,449	0.000	4.72	0	0.00	38	0	1	79,587	210,848	0.000	2.51	0	0.000	36	0	1	72,672	220,935	0.000	2.75	1	2.75	33	
9	0	4	121,065	664,929	0.000	6.61	0	0.00	63	0	6	157,010	954,758	0.000	7.64	2	2.548	64	0	6	151,338	1,013,140	0.000	7.93	1	1.32	61	
10	0	4	296,195	818,459	0.000	2.70	1	0.68	157	0	5	387,019	1,569,637	0.000	2.58	1	0.517	140	0	6	376,252	1,381,757	0.000	3.19	2	1.06	145	
11	0	1	42,795	82,730	0.000	4.67	0	0.00	27	0	3	94,646	176,558	0.000	6.34	1	2.113	34	0	15	102,020	311,477	0.000	29.41	0	0.00	40	
12	0	1	28,048	118,191	0.000	7.13	0	0.00	22	0	0	26,038	82,312	0.000	0.00	0	0.000	19	0	0	17,417	46,861	0.000	0.00	0	0.00	16	
13	0	0	41,752	79,328	0.000	0.00	0	0.00	18	0	0	45,586	82,382	0.000	0.00	0	0.000	18	0	0	12,836	27,648	0.000	0.00	0	0.00	11	
14	2	9	127,649	369,242	3.134	14.10	4	6.27	61	0	11	156,830	706,812	0.000	14.03	1	1.275	63	0	5	99,113	524,262	0.000	10.09	0	0.00	55	
15	0	2	149,896	495,132	0.000	2.67	0	0.00	90	0	3	142,310	397,943	0.000	4.22	0	0.000	56	0	3	126,051	525,202	0.000	4.76	0	0.00	50	
16	0	0	28,735	75,490	0.000	0.00	0	0.00	22	0	0	41,259	110,863	0.000	0.00	0	0.000	18	0	4	44,332	143,133	0.000	18.05	0	0.00	18	
17	0	7	238,490	704,839	0.000	5.87	1	0.84	121	0	5	303,078	802,275	0.000	3.30	1	0.660	121	0	3	219,218	662,176	0.000	2.74	1	0.91	109	
18	0	0	13,414	46,193	0.000	0.00	0	0.00	64	1	1	85,323	358,915	2.344	2.34	1	2.344	59	0	0	0	0	0.000	0.00	0	0.00	0	*7*
19	0	14	497,892	1,230,763	0.000	5.62	4	1.61	211	0	5	607,498	1,707,101	0.000	1.65	1	0.329	240	0	15	576,435	1,987,768	0.000	5.20	3	1.04	212	
20	0	1	31,215	71,392	0.000	6.41	0	0.00	15	0	1	53,411	101,645	0.000	3.74	0	0.000	15	0	0	39,976	106,379	0.000	0.00	0	0.00	15	
21	0	0	83,946	142,007	0.000	0.00	0	0.00	38	0	3	82,266	203,415	0.000	7.29	2	4.862	28	0	2	53,051	137,937	0.000	7.54	0	0.00	27	
22	0	1	62,857	146,899	0.000	3.18	1	3.18	22	0	0	81,748	199,968	0.000	0.00	0	0.000	26	0	3	87,932	235,788	0.000	6.82	1	2.27	28	
23	0	4	45,676	80,739	0.000	17.51	1	4.38	25	0	4	58,739	109,695	0.000	13.62	0	0.000	25	0	10	62,041	137,552	0.000	32.24	5	16.12	28	
24	0	1	72,565	335,164	0.000	2.76	0	0.00	39	0	1	92,521	377,356	0.000	2.16	1	2.162	33	0	1	54,661	170,691	0.000	3.66	0	0.00	38	
25	0	3	48,986	96,222	0.000	12.25	1	4.08	31	0	4	66,321	147,207	0.000	12.06	1	3.016	26	0	3	62,973	158,593	0.000	9.53	0	0.00	25	
26	0	3	81,005	421,805	0.000	7.41	0	0.00	43	0	1	86,647	584,515	0.000	2.31	1	2.308	39	0	0	5,102	34,786	0.000	0.00	0	0.00	29	*3*
27	0	4	73,677	235,288	0.000	10.86	2	5.43	38	0	0	16,199	42,020	0.000	0.00	0	0.000	20	0	0	0	0	0.000	0.00	0	0.00	0	*2*
28	0	3	94,460	328,966	0.000	6.35	0	0.00	48	0	1	118,277	474,349	0.000	1.69	0	0.000	47	0	3	113,190	587,714	0.000	5.30	0	0.00	44	
29	0	1	74,077	192,417	0.000	2.70	1	2.70	40	0	5	82,042	208,120	0.000	12.19	0	0.000	32	0	3	87,144	217,022	0.000	6.89	2	4.59	33	*1*
30	0	9	333,073	1,174,546	0.000	5.40	2	1.20	136	0	10	298,142	1,172,217	0.000	6.71	5	3.354	96	0	10	333,123	1,350,754	0.000	6.00	6	3.60	98	
31	1	2	326,390	1,812,898	0.613	1.23	0	0.00	156	0	8	439,605	2,217,020	0.000	3.64	1	0.455	175	0	9	334,127	1,919,440	0.000	5.39	3	1.80	135	
32	0	0	34,009	119,664	0.000	0.00	0	0.00	21	0	0	37,508	117,831	0.000	0.00	0	0.000	25	0	0	34,040	152,980	0.000	0.00	0	0.00	13	
33	0	1	22,184	64,170	0.000	9.02	0	0.00	16	0	1	34,563	99,124	0.000	5.79	0	0.000	14	0	0	38,004	92,577	0.000	0.00	0	0.00	16	
34	0	3	130,561	623,894	0.000	4.60	0	0.00	69	0	1	129,240	553,795	0.000	1.55	0	0.000	60	0	0	18,388	101,607	0.000	0.00	0	0.00	30	
Total/Avg.	**3**	**125**	**3,984,404**	**13,404,966**	**0.151**	**6.27**	**22**	**1.10**	**2,079**	**2**	**139**	**4,643,119**	**16,707,907**	**0.086**	**5.99**	**32**	**1.38**	**1,918**	**1**	**147**	**3,920,113**	**15,677,840**	**0.051**	**7.50**	**31**	**1.58**	**1,620**	

Summary by District

	Fatals	NFDL Injuries	Man-hours	Tons	FIR	NFDL-IR	Roof Fall Injuries	RFI-IR	Manpower	Fatals	NFDL Injuries	Man-hours	Tons	FIR	NFDL-IR	Roof Fall Injuries	RFI-IR	Manpower	Fatals	NFDL Injuries	Man-hours	Tons	FIR	NFDL-IR	Roof Fall Injuries	RFI-IR	Manpower
Barbourville	0	46	841,435	2,775,150	0.000	10.93	4	0.95	448	1	59	839,706	2,939,226	0.238	14.05	13	3.10	389	1	45	798,677	3,429,661	0.250	11.27	6	1.50	311
Harlan	2	23	830,422	2,855,222	0.482	5.54	5	1.20	455	0	27	1,075,956	4,337,102	0.000	5.02	5	0.93	434	0	33	850,036	3,627,687	0.000	7.76	4	0.94	391
Hazard	0	9	430,535	1,321,654	0.000	4.18	1	0.46	297	1	9	571,970	1,669,996	0.350	3.15	2	0.70	254	0	10	389,601	1,330,511	0.000	5.13	1	0.51	177
Martin	0	14	497,892	1,230,763	0.000	5.62	4	1.61	211	0	5	607,498	1,707,101	0.000	1.65	1	0.33	240	0	15	576,435	1,987,768	0.000	5.20	3	1.04	212
Pikeville	1	33	1,384,120	5,222,177	0.144	4.77	8	1.16	668	0	39	1,547,989	6,054,482	0.000	5.04	11	1.42	601	0	44	1,305,364	5,302,213	0.000	6.74	17	2.60	529
Total/Avg.	**3**	**125**	**3,984,404**	**13,404,966**	**0.151**	**6.27**	**22**	**1.10**	**2,079**	**2**	**139**	**4,643,119**	**16,707,907**	**0.086**	**5.99**	**32**	**1.38**	**1,918**	**1**	**147**	**3,920,113**	**15,677,840**	**0.051**	**7.50**	**31**	**1.58**	**1,620**

1) Idled 4th Quarter 2003.
2) Only operated Second Half of 2004
3) Only operated 4th Quarter 2003
4) Did not operate 3rd Quarter 2005
5) An additional NFDL Contractor Injury occurred in 2005
6) Fatality was for a Contractor in 2004
7) Only operated First Quarter of 2005

Legend
NFDL = Injuries with Non-Fatal, Days Lost
FIR = Fatal Incident Rate
NFDL-IR = Nonfatal, Days Lost-Incident Rates
RF = Roof Fall(s)
RFI-IR = Roof Fall Injuries-Incident Rates

Kentucky Department for Natural Resources

Office of Mine Safety and Licensing

Summary of Roof Fall Injuries

Table 8

								Experience					
Study No.	**Fatal**	**Reportable**	**Date**	**Time**	**Day of Week**	**Shift**	**Age**	**Total (yrs.)**	**At this Mine (yrs.)**	**At this Occupation (yrs.)**	**Occupation When Injured**	**Description**	**Injury**
		1	05/07/03	5:00 PM	Wed	3-11	34	10	2 yr 2 wks	7	CM Operator	Rock fell while miner moving	Right leg
1	1	1	06/16/04	7:30 PM	Wed	3-11	25	5 yr 6 mos	2 wk	2 wk	Roof Bolter	Roof fall in retreat mining	Fatal
		1	01/13/05	N/L	Thu	N/L	N/L	25	5 yr 6 mos	13	Shuttle Car	Struck by rock while hanging curtain	Right foot/5th toe
1 Total	**1**	**3**											
		1	12/08/03	11:30 AM	Mon	7-3	28	5	2 yr 6 mos	4	Roof Bolter	Draw rock fell	Face
		1	04/08/04	8:50 PM	Thu	3-11	34	34	2 yr 6 mos	Temporary	Foreman	Rock fell between the bolts from height of 9'4"	Head/spine
2		1	05/22/04	12:20 PM	Sat	7-3	48	16	3	8	Miner Helper	Struck by draw rock while eating	N/L
		1	07/15/04	9:30 PM	Thu	3-11	49	29	3 yr 6 mos	6	CM Operator	Struck by rib roll	Right hip
		1	02/17/05	10:30 PM	Thu	3-11	28	9	1 month	9	Roof Bolter	Struck by draw rock while bolting	Left thumb
2 Total	**0**	**5**											
		1	03/20/03	2:30 PM	Thu	7-3	38	20	7	3	Beltman	Struck by draw rock while moving	Face
		1	05/05/03	11:00 PM	Mon	3-11	36	16	4	11	Electrician	Struck by rock	Head/ribs
		1	12/31/03	12:30 PM	Wed	7-3	53	32	6 mos	16	CM Operator	Struck by rib roll	Right leg
		1	03/01/04	10:45 AM	Mon	7-3	37	13	8	12	Roof Bolter	Draw rock fell from around drill hole	Right finger
		1	05/11/04	N/L	Tue	N/L	N/L	23	2 yr 6 mos	14	Roof Bolter	Struck by drawrock while checking belt line.	N/L
3		1	07/19/04	3:40 PM	Mon	7-3	35	15	2	12	Roof Bolter	Struck by draw rock while bolting	Left hand
		1	07/23/04	3:30 PM	Fri	3-11	33	3	3	2	Mantrip	Struck by rock while operating	Right hand
		1	10/08/04	2:50 AM	Fri	11-7	46	24	4 mos	19	Foreman	Struck by draw rock	Right hand
		1	10/13/04	11:00 AM	Wed	7-3	47	29	9	18	CM Operator	Struck by draw rock	Right ankle
		1	08/19/05	N/L	Fri	N/L	N/L	10	4	9	Electrician/ Helper	Struck by drawrock	Left hand, left knee
3 Total	**0**	**10**											
4	0	1	03/11/05	4:30 PM	Fri	3-11	19	10 mos	1 month	6 mos	Roof Bolter	Draw rock fell between bolts	Head/neck
5													
6													
		1	01/16/03	5:15 PM	Thu	3-11	38	20	20	3 mos		Draw rock fell	Head
7		1	03/26/04	9:00 AM	Fri	7-3	26	8	4 yr 6 mos	3	Shield Tech	Rock fell from rib as loading	N/L
		1	04/27/04	6:30 PM	Tue	3-11	39	15	12	12		Draw rock fell as repairing bolter	Left finger
		1	07/20/04	11:00 AM	Tue	7-3	N/L	17	16	7	**Shuttle Car**	**Rock fell from roof**	**Left arm**
7 Total	**0**	**4**											
8		1	08/21/03	N/L	Thu	N/L	N/L	15	5	5	Laborer	Rock fell	Left thumb
8 Total		**1**											
	0	1	10/10/03	N/L	Fri	N/L	N/L	7	2	3	SC Operator	Rib roll fell onto leg	Foot
9		1	05/26/04	N/L	Wed	N/L	N/L	4	3	3	Timberman	Setting timbers and rock fell from between bolts	Left Shoulder
		1	11/10/04	6:15 PM	Wed	3:30-12:30	26	10	4 yr 6 mos	4 yr 6 mos	Roof Bolter	Draw rock fell	Head/shoulder
9 Total	**0**	**3**											
		1	05/02/03	N/L	Fri	N/L	N/L	17	6	6	Laborer	Draw rock fell while hanging curtain.	
10		1	10/03/03	N/L	Fri	N/L	N/L	28	8.00	8	CM Operator	Draw rock fell during retreat mining	Right shoulder/back
	0	1	04/23/04	2:00 PM	Fri	3-1	41	8	13 mos	2 yr 6 mos	CM Operator	Draw rock fell from between roof bolt and rib	Head/neck/shoulder
	0	1	07/13/05	9:25 PM	Wed	3-1	41	14	1 yr 2 mos	1 yr 2 mos	CM Operator	Draw rock fell from between roof bolt and rib	Back
10 Total	**0**	**4**											
11	0	1	02/26/04	N/L	Thu	6-2	30	10	5	10	Roof Bolter	Draw rock fell while bolting	Forearm
12													
13													

Kentucky Department for Natural Resources

Office of Mine Safety and Licensing

Summary of Roof Fall Injuries

Table 8

								Experience					
Study No.	**Fatal**	**Reportable**	**Date**	**Time**	**Day of Week**	**Shift**	**Age**	**Total (yrs.)**	**At this Mine (yrs.)**	**At this Occupation (yrs.)**	**Occupation When Injured**	**Description**	**Injury**
14		1	11/10/04	N/L	Wed	N/L	N/L	15	1	1	Roof Bolter	Draw Rock fell	Right foot
		1	04/12/05	N/L	Tue	N/L	N/L	26.50	4.50	10	CM Operator	Draw rock fell from roof while loading shuttle car	Head/left forearm
	1	1	08/03/05	10:30 PM	Wed	3:30-12:30	39	10	10 1/2 mos	9wk	Section Foreman	Roof fall while mining pillars	Fatal
	1	1	08/03/05	10:30 PM	Wed	3:30-12:30	23	10 mos	8 mos	N/L	Scoop	Roof fall while mining pillars	Fatal
		1	08/04/05	N/L	Thu	N/L	N/L	25	3.23	1.53	Supervisory		
14 Total	**2**	**5**											
15													
16													
17	0	1	09/11/03	9:20 AM	Thu	7-3	27	4	8 mos	2	Roof Bolter	Draw rock fell from roof	Right hand
		1	12/10/04	N/L	Fri	N/L	N/L	2.57	0.17	1.57	Scoop Operator	Draw rock fell while working on brattices	Back
	0	1	06/24/05	11:30 PM	Fri	3-10	38	18	26 wk	14	Section Foreman	Miner was extracting coal and intersection fell	Left leg
17 Total	**0**	**3**											
18	1	1	08/02/04	3:45 PM	Mon	3:30-1:30	38	14	3 1/2 mos	8 yr 8 mos	Roof Bolter	Watching CM cutting and roof fell	Fatal
19		1	02/07/03	2:10 PM	Fri	7:30-4	32	15	4 yr 8 wk	1	Roof Bolter	Struck by draw rock while bolting	Head/ears
		1	05/22/03	5:55 PM	Thu	2:30-11:30	40	22	4 yr 6 mos	12	CM Operator	Struck by draw rock while moving	Right side of body - hip/leg
		1	06/05/03	10:45 PM	Thu	2:30-11:30	33	13	9	13	Scoop Operator	Draw rock fell between rib and roof bolt	Back
		1	01/26/04	6:30 PM	Mon	3:30-11:30	33	10	2	4	Roof Bolter	Draw rock fell while bolting	Back
		1	01/04/05	4:30 PM	Tue	10:30-7:30	27	6	1 wk	6	Laborer	Let ATRS down and loose rock dislodged	Right leg
		1	01/07/05	8:30 PM	Fri	2:30-11:30	45	15	1 wk	6	Shuttle Car	Removing rock from miner when rock fell on him	Right hand
		1	07/27/05	N/L	Wed	7-4:30	39	20	10 mos	10 mos	Section Boss	Draw rock fell while marking center line	Face
		1	09/13/05	N/L	Tue	N/L	N/L	26	7	4	CM Operator	Draw rock fell while cutting 8 Right	Head
19 Total	**0**	**8**											
20													
21		1	05/03/04	N/L	Mon	N/L	N/L	20	8	15	Shuttle Car	Rock on corner of coal rib came under edge of canopy	Hand
	0	1	05/04/04	6:30 PM	Tue	2-11	46	8	1	8	Beltman	Rock fell from between rib and bolt	Back
21 Total		**2**											
22		1	01/13/03	11:15 PM	Mon	2:30-11:30	31	5	5	5	Laborer	Draw rock fell as cleaning travelway on beltline	Shoulder/back
		1	02/28/05	6:30 PM	Mon	2-11	30	3	3 mos	3	Roof Bolter	Draw rock fell as installing bolt	Left foot
22 Total	**0**	**2**											
		1	04/22/03	5:30 PM	Tue	4-12	27	1	1 mos	1	Beltman	Draw rock fell while moving	Right hand
		1	01/09/03	8:45 PM	Thu	4-12	22	2	1	2	Beltman	Rock fell	Neck - stitches
		1	06/10/03	9:00 AM	Tue	7-3:30	39	21	1 yr 6 mos	2 yr 5 mos	Miner Helper	Rock fell during retreat mining	N/L
		1	06/10/03	N/L	Tue	N/L	N/L	20	1.69	1.30	CM Helper	Draw rock fell from top	N/L
		1	08/27/03	7:40 PM	Wed	4-12	32	8	5 mos	4	Roof Bolter	Draw rock fell	Right arm
		1	02/01/05	2:45 PM	Tue	4-12	40	N/L	N/L	N/L	Roof Bolter	Draw rock fell	Rib
23 Total	**0**	**6**											
24		1	01/02/04	7:30 AM	Fri	2-10	46	27	6 mos	N/L	CM Operator	Draw rock fell while mining left sump	N/L

Kentucky Department for Natural Resources

Office of Mine Safety and Licensing

Summary of Roof Fall Injuries

Table 8

								Experience					
Study No.	**Fatal**	**Reportable**	**Date**	**Time**	**Day of Week**	**Shift**	**Age**	**Total (yrs.)**	**At this Mine (yrs.)**	**At this Occupation (yrs.)**	**Occupation When Injured**	**Description**	**Injury**
25		1	04/19/04	N/L	Mon	N/L	N/L	0.69	0.69	0.69	Beltman	Rock fell from roof	Hand
		1	01/18/05	N/L	Tue	N/L	N/L	4	4	3	Roof Bolter	Sitting on rear of roof bolter when rock fell while idle	Head
25 Total	**0**	**2**											
26	0	1	05/13/04	9:30 PM	Thu	3-11	26	8	1	2 mos	Production Foreman	While observing pillar work, rib rolled dislodging a timber	Head
27		1	02/16/05	9:00 AM	Wed	6-3	31	4 yr 8 mos	8 mos	1 yr 9 mos	CM Operator	Rock fell as miner was backing up	Back
		1	04/13/05	8:30 PM	Wed	3-11	40	15	5 mos	1 month	CM Operator	Draw rock fell as cutting coal	Left knee
27 Total	**0**	**2**											
28													
29		1	02/26/03	12:52 AM	Wed	3-11	56	39	1	1	Roof Bolter	Draw rock fell while bolting	Right hand
		1	08/13/03	12.35 AM	Wed	11-7	30	3 yr 7 mos	7 mos	3 yr 7 mos	Scoop Operator	Draw rock fell while loading	Left shoulder
		1	07/26/05	N/L	Tue	N/L	N/L	12	0.57	11.50	Roof Bolter	Rock fell from roof while bolting	Left hand/5th finger
29 Total	**0**	**3**											
30		1	01/10/03	6:15 PM	Fri	3-12	48	30	7	25	Electrician	Draw rock fell while he was working outby Section 001-0	Back
		1	04/26/03	9:10 AM	Sat	7-3	44	25	3	17	CM Operator	Cap coal fell while operating CM	Left hand
		1	05/12/03	N/L	Mon	N/L	N/L	5	1	5	SC Operator	Draw rock fell while assisting in move	Head and Neck
		1	05/16/03	7:20 PM	Fri	3-12	44	25	2	2	CM Operator	Draw rock fell while operating CM	Right hand
		1	08/12/03	12:50 PM	Tue	3-12	39	11	1 yr 6 mos	4	Foreman	Conducting safety observation of CM operator, draw rock fell	Head
		1	09/02/03	7:15 PM	Tue	3-12	25	6	1	6	Shuttle Car	Removing rock from miner cable, when draw fell causing him to twist knee	Knee
		1	04/21/04	N/L	Wed	N/L	N/L	13	N/L	N/L	Supervisory	Draw rock fell while setting up roof bolter	Right shoulder
		1	05/11/04	5:00 PM	Tue	3-12	26	7	6 mos	7	Shuttle Car	Draw rock fell while drilling test hole #3 Entry	Foot
		1	08/12/04	10:15 AM	Thu	7-3	44	20	9	20	Shuttle Car	Draw rock fell	Neck /shoulder
		1	10/26/04	9:00 AM	Tue	7-3	42	21	4 mos	13	Section Foreman	Rib roll fell pushing him into tailpiece	N/L
		1	10/30/04	10:30 PM	Sat	3-12	26	5	5	3	Roof Bolter	Draw rock fell as T-Bar was let down	Right index finger
		1	02/07/05	12:15 PM	Mon	7-3	25	5	3	1	Roof Bolter	Rib popped while bolting #1 Entry on #2 Section	Right leg
		1	04/08/05	11:15 AM	Fri	7-3	23	3	7 mos	2 mos	Roof Bolter	Draw rock fell while bolting #1 Entry on #2 Section	Right knee
30 Total	**0**	**13**											
31		1	01/07/03	9:30 AM	Tue	6-4	23	3 yr 6 mos	1	1	Shield Operator	Rock fell while operating shield	Left hand
		1	03/29/03	12:30 AM	Sat	6-6	39	19 yr 6 mos	2	7	Longwall Foreman	Rock fell while setting cribs	Back
		1	08/25/03	N/L	Mon	4:30-10	27	2 yr 16 wk	2 yr 16 wk	2 yr 16 wk	Roof Bolter	Draw rock fell while bolting	Neck/back
		1	08/19/04	8:00 PM	Thu	4-1:30	46	26	8	14	Section Foreman	Pulling a piece of draw rock that bounced and hit foreman	Left leg
31 Total	**0**	**4**											
32													
33													
34													

N/L = Not Listed

Kentucky Department for Natural Resources

Office of Mine Safety and Licensing

Training Plans for Underground Mines

Table 9

Study No.	Position of Trainer	Time (hrs)	Subject	No. of Subjects	Course Material
		Part 48.8 Annual Refresher Training Roof or Ground Control			
1			Plan not available		
2	Safety Director	1.00	Roof or ground control (extended cuts) and ventilation plans	3	Act 30 CFR Part 48 and applicable health and safety standards, MSHA instruction guides, manuals, pamphlets, overhead transparencies, films and slides, company policy rules, actual devices and equipment, Manikin handout materials, SCSR Training Model, Filer-type self rescuer training models
3	VP-Safety & Health	1.00	Roof or ground control and ventilation plans	2	Training modules, mine roof control plan, mine ventilation plan and mine map
4	Safety Director	1.00	Roof or ground control, ventilation, emergency evacuation and firefighting plans	4	Mine's roof control plan, ventilation plan, mine map, emergency evacuation and firefighting plan in effect at mine, other materials, as applicable
5	Safety Director	1.00	Roof or ground control, ventilation, emergency evacuation and firefighting plans	4	Mine's roof control plan, ventilation plan, mine map, emergency evacuation and firefighting plan in effect at mine, other materials, as applicable
6	President	1.00	Roof or ground control, ventilation, emergency evacuation and firefighting plans	4	Mine's roof control plan, ventilation plan, mine map, emergency evacuation and firefighting plan in effect at mine, other materials, as applicable
7	Safety Director	1.00	Roof or ground control and ventilation	2	Training modules, mine roof control plan, ventilation plan and mine map. Safety precautions and special equipment for Extended Cut Mining. Review of precautions for polyurethane foam use as outlined in approved plans.
8	Supt.	1.00	Roof or ground control and ventilation plans	2	Training modules, mine roof control plan, mine ventilation plan and mine map
9	General Mine Foreman	1.00	Roof or ground control, ventilation, emergency evacuation and firefighting plans	4	Mine's roof control plan, ventilation plan, mine map, emergency evacuation and firefighting plan in effect at mine, other materials, as applicable
10	Safety Manager	1.00	Roof and ventilation plans, extended cut procedures along with associated special equipment, CO monitoring system fire detection	4	Mine roof control plan, mine ventilation plan, mine map
11	General Mine Foreman	1.00	Roof or ground control, ventilation, emergency evacuation and firefighting plans	4	Mine's roof control plan, ventilation plan, mine map, emergency evacuation and firefighting plan in effect at mine, other materials, as applicable
12	Owner	1.00	Roof or ground control, ventilation, emergency evacuation and firefighting plans	4	Mine's roof control plan, ventilation plan, mine map, emergency evacuation and firefighting plan in effect at mine, other materials, as applicable
13	Safety Director	1.00	Roof or ground control, ventilation, emergency evacuation and firefighting plans	4	Mine's roof control plan, ventilation plan, mine map, emergency evacuation and firefighting plan in effect at mine, other materials, as applicable
14			Plan not available		
15	General Supt.	1.00	Roof or ground control, ventilation, emergency evacuation and firefighting plans, EXT Cuts	5	Mine's roof control plan, ventilation plan, mine map, emergency evacuation and firefighting plan in effect at mine, other materials, as applicable
16	Supt.	1.00	Roof and ventilation plans, extended cut plan.	3	Mine's roof control plan, ventilation plan, mine map, extended cut plan
17	Supt.	1.00	Roof or ground control, ventilation, emergency evacuation and firefighting plans	4	Mine's roof control plan, ventilation plan, mine map, emergency evacuation and firefighting plan in effect at mine, other materials, as applicable
18			Plan not available		
19	Safety Coordinator	0.50	Roof control, ground control and ventilation	3	Materials to be selected for each individual segment of training and may include: MSHA instruction guides, manuals, pamphlets, overhead transparencies, films and slides, company policy rules, mine's roof control plan, ventilation plan, mine map, emergency evacuation and firefighting plan in effect at mine
20	Supt.	0.50	Roof or ground control, ventilation, emergency evacuation and firefighting plans	5	Materials to be selected for each individual segment of training and may include: MSHA instruction guides, manuals, pamphlets, overhead transparencies, films and slides, company policy rules, mine's roof control plan, ventilation plan, mine map, emergency evacuation and firefighting plan in effect at mine
21	Supt.	1.50	Roof or ground control and ventilation	3	Materials to be selected for each individual segment of training and may include: MSHA instruction guides, manuals, pamphlets, overhead transparencies, films and slides, company policy rules, mine's roof control plan, ventilation plan, mine map, emergency evacuation and firefighting plan in effect at mine

Kentucky Department for Natural Resources
Office of Mine Safety and Licensing
Training Plans for Underground Mines
Table 9

Study No.	Position of Trainer	Time (hrs)	Subject	No. of Subjects	Course Material
		Part 48.8 Annual Refresher Training Roof or Ground Control			
22	Supt.	1.50	Roof or ground control and ventilation	3	Materials to be selected for each individual segment of training and may include: MSHA instruction guides, manuals, pamphlets, overhead transparencies, films and slides, company policy rules, mine's roof control plan, ventilation plan, mine map, emergency evacuation and firefighting plan in effect at mine
23		2.00	Roof and rib control plans and ventilation	3	Mine's roof control plan, ventilation plan, mine map, emergency evacuation and firefighting plan in effect at mine, other materials, as applicable and Extended Cut Mining Method Training Plan Addendum
24	Owner	.0.50	Roof or ground control, ventilation, emergency evacuation and firefighting plans	4	Materials to be selected for each individual segment of training and may include: MSHA instruction guides, manuals, pamphlets, overhead transparencies, films and slides, company policy rules, mine's roof control plan, ventilation plan, mine map, emergency evacuation and firefighting plan in effect at mine
25	Vice President	2.00	Roof and rib control plans and ventilation	3	Mine's roof control plan, ventilation plan, mine map, emergency evacuation and firefighting plan in effect at mine, other materials, as applicable and Extended Cut Mining Method Training Plan Addendum
26	Safety Director	1.00	Roof control, ground control and ventilation	3	Materials to be selected for each individual segment of training and may include: MSHA instruction guides, manuals, pamphlets, overhead transparencies, films and slides, company policy rules, and devices at the mine site
27	Safety Tech	1.00	Roof or ground control, ventilation, emergency evacuation and firefighting plans	4	Materials to be selected for each individual segment of training and may include: MSHA instruction guides, manuals, pamphlets, overhead transparencies, films and slides, company policy rules, mine's roof control plan, ventilation plan, mine map, emergency evacuation and firefighting plan in effect at mine
28	Safety Director	1.00	Roof control, ground control and ventilation	3	Materials to be selected for each individual segment of training and may include: MSHA instruction guides, manuals, pamphlets, overhead transparencies, films and slides, company policy rules, and devices at the mine site
29	Supt.	1.00	Roof or ground control, ventilation, emergency evacuation and firefighting plans	4	Materials to be selected for each individual segment of training and may include: MSHA instruction guides, manuals, pamphlets, overhead transparencies, films and slides, company policy rules, mine's roof control plan, ventilation plan, mine map, emergency evacuation and firefighting plan in effect at mine
30			Plan not available		
31	Supt.	0.50	Roof or ground control, ventilation, emergency evacuation and firefighting plans	4	Materials to be selected for each individual segment of training and may include: MSHA instruction guides, manuals, pamphlets, overhead transparencies, films and slides, company policy rules, mine's roof control plan, ventilation plan, mine map, emergency evacuation and firefighting plan in effect at mine
32	Owner	0.50	Roof or ground control, ventilation, emergency evacuation and firefighting plans	4	Materials to be selected for each individual segment of training and may include: MSHA instruction guides, manuals, pamphlets, overhead transparencies, films and slides, company policy rules, mine's roof control plan, ventilation plan, mine map, emergency evacuation and firefighting plan in effect at mine.
33	Owner	0.50	Roof control, ground control and ventilation	3	Materials to be selected for each individual segment of training and may include: MSHA instruction guides, manuals, pamphlets, overhead transparencies, films and slides, company policy rules, and devices at the mine site
34			Plan not available		

Kentucky Department for Natural Resources

Table 10

Office of Mine Safety and Licensing

Summary of Out of State Roof Control Plans (Retreat Mining)

Table 10

		Main Roof		Immediate Roof		Coalbed		Bottom		Roof Bolt	Resin Bolt						
Study No.	**Maximum Cover (ft.)**	**Type**	**Thk (ft.)**	**Type**	**Thk (ft.)**	**Seam**	**Thk (in.)**	**Type**	**Thk (ft.)**	**Minimum Length (ft.)**	**Minimum Length (ft.)**	**Mines Below**	**Mines Above**	**Elevation**	**Depth of Cut (ft.)**	**Last Permanent Support**	**Footnote No.**
Virginia																	
VA1	750	SH/SSH	20	SH	10	Lower Banner	40	SH/SSH	5		5				40	2nd Row	
VA2															36	2nd Row	
VA3	1,200	SH/SSH	43	SH	10	Lower Banner	54	SH	6		5				40	2nd Row	
West Virginia																	
WV1	450	SS	70	SH	15	Upper Mercer	100	SH/SSH SS	2 15	4	4				40		
WV2	880	SS		SH	10-15	Lower Kittanning	78	SH	10		6					2nd Row	

Legend	
SH =	Shale
SS =	Sandstone
SSH =	Sandy Shale

Kentucky Department for Natural Resources

Table 11

Office of Mine Safety and Licensing

Comparison of Critical Factors

Table 11

Study No.	2004 - 2005 Fatal	2004 - 2005 NFDL Injury	2004 - 2005 Serious Roof Fall Injuries	2004-2005 Number of Roof Falls	Safety Factor LC-3	Max W/D Ratio	Min W/D Ratio	2004 -2005 FIR	2004 - 2005 NFDL-IR	2004 - 2005 RFI-IR	2004 - 2005 Roof Fall-IR	Man-hours YTD 3rd Qtr 2005	Tons YTD 3rd Qtr 2005	2004 Man-hours	2004 Tons
1	1	10	2	4	>1.3 : <2	0.50	1.40	0.990	9.90	1.98	3.96	85,539	170,476	116,556	402,789
2	0	32	4	4	<1.3	0.32	0.69	0.000	14.67	1.83	1.83	201,085	760,946	235,055	897,801
3	0	47	7	16	<1.3	0.43	0.95	0.000	20.40	3.04	6.94	203,702	646,338	257,121	944,444
4	0	1	1	1	<1.3	0.65	0.86	0.000	1.86	1.86	1.86	75,393	278,213	31,897	108,763
5	0	3	0	0	>2	1.34	0.87	0.000	11.46	0.00	0.00	44,972	119,429	7,400	2,071
6	0	5	0	0	>1.3 : <2	1.47	1.69	0.000	8.10	0.00	0.00	90,164	430,715	33,288	44,204
7	0	7	3	14	>2	0.43	1.26	0.000	4.68	2.01	9.37	140,580	369,033	158,389	539,154
8	0	2	0	0	>1.3 : <2	0.36	0.46	0.000	3.28	0.00	0.00	42,357	98,449	79,587	210,848
9	0	10	2	5	>1.3 : <2	0.64	1.87	0.000	7.19	1.44	3.60	121,065	664,929	157,010	954,758
10	0	9	2	23	<1.3	0.24	1.10	0.000	2.63	0.59	6.73	296,195	818,459	387,019	1,569,637
11	0	4	1	3	>1.3 : <2	0.41	2.64	0.000	5.82	1.46	4.37	42,795	82,730	94,646	176,558
12	0	1	0	0	>2	1.15	1.30	0.000	3.70	0.00	0.00	28,048	118,191	26,038	82,312
13	0	0	0	0	>2	0.71	1.30	0.000	0.00	0.00	0.00	41,752	79,328	45,586	82,382
14	2	20	5	6	<1.3	0.29	0.82	1.406	14.06	3.52	4.22	127,649	369,242	156,830	706,812
15	0	5	0	13	>2	0.78	2.39	0.000	3.42	0.00	8.90	149,896	495,132	142,310	397,943
16	0	0	0	0	>2	1.11	0.99	0.000	0.00	0.00	0.00	28,735	75,490	41,259	110,863
17	0	12	2	10	>1.3 : <2	0.62	1.07	0.000	4.43	0.74	3.69	238,490	704,839	303,078	802,275
18	1	1	1	1	>1.3 : <2	1.20	1.46	2.026	2.03	2.03	2.03	13,414	46,193	85,323	358,915
19	0	19	5	18	<1.3	0.58	1.97	0.000	3.44	0.90	3.26	497,892	1,230,763	607,498	1,707,101
20	0	2	0	0	>2	1.03	1.03	0.000	4.73	0.00	0.00	31,215	71,392	53,411	101,645
21	0	3	2	5	>2	1.21	1.21	0.000	3.61	2.41	6.02	83,946	142,007	82,266	203,415
22	0	1	1	5	>2	1.71	2.18	0.000	1.38	1.38	6.92	62,857	146,899	81,748	199,968
23	0	8	1	1	>2	1.32	2.87	0.000	15.32	1.92	1.92	45,676	80,739	58,739	109,695
24	0	2	1	1	>1.3 : <2	0.73	1.90	0.000	2.42	1.21	1.21	72,565	335,164	92,521	377,356
25	0	7	2	3	<1.3	0.74	1.73	0.000	12.14	3.47	5.20	48,986	96,222	66,321	147,207
26	0	4	1	1	<1.3	0.95	1.97	0.000	4.77	1.19	1.19	81,005	421,805	86,647	584,515
27	0	4	2	2	<1.3	0.59	1.92	0.000	8.90	4.45	4.45	73,677	235,288	16,199	42,020
28	0	4	0	1	>2	1.04	2.59	0.000	3.76	0.00	0.94	94,460	328,966	118,277	474,349
29	0	6	1	13	>1.3 : <2	0.92	1.71	0.000	7.69	1.28	16.65	74,077	192,417	82,042	208,120
30	0	19	7	9	>1.3 : <2	0.70	1.12	0.000	6.02	2.22	2.85	333,073	1,174,546	298,142	1,172,217
31	1	10	1	15	>1.3 : <2	0.74	1.57	0.261	2.61	0.26	3.92	326,390	1,812,898	439,605	2,217,020
32	0	0	0	0	<1.3	0.61	10.00	0.000	0.00	0.00	0.00	34,009	119,664	37,508	117,831
33	0	2	0	0	>2	0.89	2.08	0.000	7.05	0.00	0.00	22,184	64,170	34,563	99,124
34	0	4	0	0	<1.3	1.04	0.27	0.000	3.08	0.00	0.00	130,561	623,894	129,240	553,795
Total/Avg.	**5**	**264**	**54**	**174**				**0.116**	**6.12**	**1.25**	**4.03**	**3,984,404**	**13,404,966**	**4,643,119**	**16,707,907**

Note All values for 2005 are Year to Date 3rd Quarter 2005

Production More Than	Production Less Than	2005 No. of Mines	Visits	2004 No. of Mines
0	200,000	16	1	14
200,000	500,000	9	0	8
500,000	1,000,000	6	2	8
1,000,000	2,500,000	3	2	4
Total		**34**	**5**	**34**

Kentucky Department for Natural Resources

Office of Mine Safety and Licensing

MSHA Recommendations for the Prevention of Roof Falls

Roof Fall Fatalities for 2003-2005

Table 12

Recommendation	Warrior Coal Cardinal Mine	Roblee Coal Hacker's Creek No. 1	Bell County Coal Coal Creek	Dags Branch Coal No. 6	Reedy Coal Mine No. 25	Coal River Mining Tiny Creek	South Central Coal South Central	Rosebud Mining Tracy Lynne	Stillhouse Mining Mine No. 1
Conduct a thorough visual examination of the roof, face, and ribs and ensure permanent supports are installed prior to performing work or mining through into unsupported areas.	X	X	X	X	X		X		X
Conduct a risk assessment, identify all possible hazards and ensure you are positioned in a safe area.							X		
Ensure that the provisions of the approved Roof Control Plan are understood and followed by all miners.	X				X	X	X	X	
Be alert for changing roof conditions and install additional roof supports where necessary.	X	X	X	X	X	X		X	X
Ensure that mining methods protect miners from hazards of unsupported roof.							X		
Always stand or work under supported roof, and do not travel inby the last row of permanent roof supports.						X	X		
Install and examine test holes regularly for changes in roof strata.			X					X	
Conduct sound and vibration roof tests where appropriate	X								
Always hang reflectors or other warning devices prior to mining				X					
Apply additional safety procedures or precautions in areas where geological changes and anomalies in strata, such as cracks, are observed.		X	X		X				X
Be alert for and recognize visible warning devices or physical barriers located at the end of permanent roof support.							X		
Know and follow the extended cut provisions of the approved roof control plan.				X					
Never travel inby the second row of permanent roof supports from an extended cut.				X			X		
Never mine a working face into an unsupported area or intersection.						X			
Know and follow the approved pillaring procedures in the roof control plan.			X						X
Ensure that the approved pillar extraction sequence is applicable t the panel, as developed, before second mining.									X
Ensure that miners are not needlessly positioned near the pillar lin or inby turn posts.					X				
Train all miners in proper escape and evacuation procedures during retreat mining		X	X						

Appendix

Appendix A

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Appendix B

Résumés of Authors

John E. Feddock, P.E.

Education:

Graduate Courses - Finance
Case Western Reserve University,
Cleveland, Ohio, 1975 - 1976

Master of Science - Mining Engineering (Mineral Economics, Rock Mechanics)
Columbia University, Henry Krumb School of Mines,
New York, New York, 1972

Bachelor of Science - Mechanical Engineering
Columbia University, School of Engineering and Applied Science,
New York, New York 1969

Background:

2001 - Present	Senior Vice President Marshall Miller & Associates, Lexington, Kentucky
1998 - 2001	Senior Vice President
1996 - 1998	Vice President - Mining and Minerals Marshall Miller & Associates, Bluefield, Virginia
1989 - 1996	Vice President - Mining L.A. Gates Company, Beckley, West Virginia
1988 - 1989	President Feddock Engineering Company, Lexington, Kentucky
1986 - 1988	Vice President - Engineering, Geology and Properties Island Creek Corporation, Lexington, Kentucky
1982 - 1986	Chief Engineer Rochester & Pittsburgh Coal Company, Indiana, Pennsylvania
1979 - 1982	Fuel Supply Manager Keystone Conemaugh Project, Indiana, Pennsylvania
1976 - 1979	Senior Mining Engineer GPU Service Corporation, Reading, Pennsylvania
1973 - 1976	Maintenance Superintendent and Project Engineer Morton Salt Company, Painesville, Ohio
1972 - 1973	Mine Engineer Bethlehem Mines Corporation, Ebensburg, Pennsylvania
1971 - 1972	Research Assistant Krumb School of Mines, Columbia University, New York, New York
1969 - 1970	Tunnel Engineer Poirier McLane Raymond DiMenna Joint Venture, New York, New York

Certifications:

Registered Professional Engineer, Illinois, Certification No. 062-045536
Registered Professional Engineer, Kentucky, Certification No. 15248
Registered Professional Engineer, Ohio, Certification No. 38974
Registered Professional Engineer, Pennsylvania, Certification No. 024352
Registered Professional Engineer, Utah, Certification No. 368993
Registered Professional Engineer, Virginia, Certification No. 034257
Registered Professional Engineer, West Virginia, Certification No. 10391
Registered Professional Surveyor, West Virginia, Certification No. 1015
Certified MSHA Trainer
MSHA 8 Hour Annual Refresher

Memberships:

Society for Mining, Metallurgy and Exploration (SME) of AIME
Central Appalachian Section of SME
American Society of Mechanical Engineers

Professional Experience:

1996 - Present	Consultant specializing in Mineral Due-Diligence, Management of mineral companies including bankruptcy, Financial Analysis, Valuation, Mine Design, Expert Witness Testimony, Attorney Technical Support, Equipment Application and Insurance Claim Analysis. Responsible for direction, coordination, scheduling, and review of engineering projects investigated by staff engineers and consultants in the mineral and construction industries. Principal Engineer responsible for due-diligence reviews of both underground and surface mines and mining related facilities, financial analysis of mining operations, and the valuation of mining property, plant and equipment. Primary Consultant providing expert witness testimony, attorney technical support, and insurance claim analysis, specific cases involve: longwall mining, blasting, subsidence, groundwater impacts, lost coal claims, personal injury, production capability, coal contracting, and other mining engineering issues. Past projects include longwall equipment application and performance, subsidence prediction and control, surface mine planning and evaluation, coal quality assessment, blasting damage risk, equipment entrapment damage assessment and recovery, business interruption losses, and operations analysis. Experience spans coal mining, quarry operations, tunnel and shaft construction, property management, geo-technical and rock mechanics studies and environmental assessments.
1989 - 1996	Provided mining engineering and technical support to various mining and civil clients. Supervised and managed projects in mine planning, longwall applications, subsidence control, blasting damage, operations analysis, and equipment operation. Involved in over 80 cases where background, experience, and knowledge had been used to evaluate mining impacts on property, equipment, and safety. Prepared background reports, assisted in depositions, been deposed, and testified as an expert. Prepared affidavits and declarations on behalf of clients and provided expert technical support.
1988 - 1989	Provided mining engineering and expert technical support to mining events on reserve acquisition and operations analysis. The firm was dedicated to implementing Quality in mining engineering, production, and management.

Professional Experience (Cont.):

1986 - 1988	Directed all engineering services, including property acquisition and disposal, at all divisions and corporate headquarters for this major coal company which produced in excess of 20 million TPY. Managed the engineering department with as many as 170 persons and an annual budget in excess of $10 million.
1986 – 1988	Supervised property and coal reserve evaluations, disposals, and acquisitions. Settled several trespass issues including two that were in arbitration. Approved contract operators selected for deep and surface mining and participated as primary corporate officer in three major divestitures of coal reserves and plant facilities. Supervised negotiations with major coal property holding companies in Virginia, West Virginia, and Kentucky.
	Directed the economic justification, planning, contracting, and completion of over $50 million per year of construction and equipment expenditures. Construction projects included several shafts, buildings, silos, material handling, and preparation plant facilities.
	Supervised the development of a longwall subsidence monitoring program including vibration monitoring, settlement prediction and damage assessment and reparation administration. Directed a longwall performance evaluation of six company mines and coordinated a long term, comprehensive program of longwall system replacement and equipment rebuild.
	Coordinated a comprehensive coal quality forecasting program incorporating statistical process control of mine production with company laboratory operation.
1982 - 1986	Directed all engineering services, including geology and private property damage assessment, at all divisions and corporate headquarters for this major coal company which produced in excess of 9 million TPY. Managed the engineering department with 110 persons and an annual budget in excess of $5 million.
	Developed surface mine engineering and environmental departments within the company to give timely response to repermitting and environmental compliance under Pennsylvania's Primacy of the Surface Mine Control and Reclamation Act of 1977 (SMCRA). As a member of the Environmental Committee of the Keystone Coal Association and the AMC Subsidence Workgroup, participated in public forums and testimony regarding the impact of various Federal and State legislation upon the mining industry.
1979 - 1982	Administered coal supply agreements with a value of US $240 million between utility owners and captive coal suppliers. As a member of a four person administrative team, acted as liaison between a consortium of ten utilities and the operation of two 1800 MW coal-fired generating stations which burn an aggregate eight million TPY. Reviewed and approved annual capital and expense budgets and mining plans of captive suppliers' underground mines. Coordinated consultant inspections, evaluations, and reports.

Professional Experience (Cont.):

1979 – 1982 Instituted and coordinated the development of a linear, stochastic program computer model to select the most economical coal supplies for a generating station over a 35-year period. The model incorporated alternative sources of supply (short, intermediate, and long term), coal price forecasts, market constraints, station operating parameters and material handling constraints. A detailed report on the coal supply strategy was accepted and based on the technical and economic evaluations, several long term agreements were renegotiated.

1976 - 1979 Supervised utility funded coal exploration programs and technical evaluations of coal mines, dedicated reserves, and coal supply and utilization problems for three wholly owned electric utilities, which burned 16 million TPY. Provided technical expertise and developed numerous interactive language computer programs to evaluate coal preparation schemes, coal mining problems, coal sampling and environmental regulations. A coal cleaning versus FGD strategy was developed.

Chaired an interutility Task Force to select and develop coal supplies for an innovative technology cleaning plant as an alternative to scrubbing. Evaluated the reliability of supply and coal preparation characteristics of several coal producers to generate a purchasing philosophy for a multi-unit, jointly owned 1850 MW generating station complex which burned five million TPY.

1973 - 1976 Supervised a 60-person Maintenance Department for a 1.15 million TPY rock salt mining and milling operation. Instituted preventive maintenance programs and a satellite maintenance area. As Project Engineer, design, acquisition, installation and economic justification of modifications and additions to the plant and mine facility.

1972 - 1973 Performed the duties of a Mine Engineer at the Revloc, No. 32 Mine and at the Division Office where responsibilities concentrated on the economic and financial analysis of mining projects.

1971 - 1972 Participated in Rock Mechanic Studies at an iron ore mine in eastern Pennsylvania.

Publications and Presentations:

"The Unique Nature of Mineral Property Appraisal," American Society of Appraisers, Kentucky Chapter Meeting, Louisville KY, June, 2004.

"Economic Benefits of Coal-based Synthetic Fuel – 1997-2007", Private presentation for Headwaters, Inc, Lexington, KY, May, 2004.

"Economic Benefits of Coal-based Synthetic Fuel • 1998-2007 Produced under Section 29 of the Internal Revenue Code, As promulgated through the Oil Windfall Profits Tax Act of 1980," coauthored with Justin S. Douthat, P.E., December 2003.

"Valuation of Minerals in Condemnation Proceedings Hypothetical Application of Valuation Methods," Conference of Government Mining Attorneys (COGMA), Knoxville, TN, September 2003.

"Determination of Rock Strength Properties Using Geophysical and Ultrasonic Logging in Exploration Drill Holes," International Conference on Ground Control in Mining, Morgantown, WV, August 2003.

Publications and Presentations (Cont.):

"Haul Roads" – Chapter 10, SME Mining Reference Handbook, Lowrie, Raymond L., P.E., Editor, Society for Mining, Metallurgy, and Exploration, Inc., Littleton, CO, 2002.

"Permitting of New Mining Operations, Problems & Possibilities" Electric Power Research Institute – Coal Markets Workshop, Hilton Washington Dulles Airport, Herndon, Virginia, June 2002.

"Engineering Aspects of Synfuel Projects" coauthored with Justin S. Douthat, P.E. at the Central Appalachian Section of the Society of Mining Engineers of the American Institute of Mining, Metallurgy and Exploration (CAS/SME/AIME) Spring Meeting, Marriott Griffin Gate Resort, Lexington, Kentucky, April 2001.

"Subsidence and Groundwater Impacts", Central Appalachian Section of the Society of Mining Engineers of the American Institute of Mining, Metallurgy and Exploration (CAS/SME/AIME) Spring Meeting, Martha Washington Inn, Abingdon, VA, June 2000.

"Permitting and the Haden Decision" Energy and Mineral Law Foundation Workshop, Ft. Myers Beach, Florida February 2000.

"Subsidence and Ground Water" June 10, 1999, Abingdon, Virginia, presented at the Central Appalachian Section of the Society of Mining Engineers Conference, co-author Ronald Mullennex C.P.G.

"Due Diligence: Reserve Assessment and Engineering Considerations," March 1, 1999, St. Pete Beach Florida, presented at the Financial Times Energy/Coal Outlook Conference, co-authors Marshall S. Miller and K. Scott Keim.

"Engineering Aspects of Mountaintop Surface Mining," The 1998 Bluefield Coal Rally sponsored by the Greater Bluefield Chamber of Commerce, Panel Discussion of Mountaintop Mining, Fincastle Country Club, Bluefield, Virginia, October 1998.

"Mine Planning and Production Costs for MTR and Non-MTR Mining," Economic Committee of the Governor's Task Force on Mountaintop Removal and Related Mining Methods, Marshall University Graduate Center, Charleston, West Virginia, October 1998.

"Practical Applications of Geology and Insurance in Recovering Longwalls," Longwall USA International Conference, D.L. Lawrence Convention Center, Pittsburgh, Pennsylvania, June 1998.

"Longwalls in Peril – The Roles of Geology and Insurance," CAS/SME-WVCMI Joint Meeting, The Greenbrier, White Sulfur Springs, West Virginia, October 1997.

"Coal Mining: Development, Operations and Management," Special Institute on Mining and Environmental Law for Trust Officers and Land Managers, Eastern Mineral Law Foundation, Charleston, West Virginia, September 1991.

"Horizontal Ground Movements and Mining Damage," Mine Subsidence - Prediction and Control Symposium, Association of Engineering Geologists, 33rd Annual Meeting, Pittsburgh, Pennsylvania, October 1990.

Publications and Presentations (Cont.):

"Engineering Quality into Surface Mine Planning," Surface Mining And Reclamation Conference, Charleston, West Virginia, April 1990.

"PRODUCTIVITY . . . Who is Responsible for Improving It?" Pittsburgh Section - SME Pittsburgh, Pennsylvania, March 1990.

"Charting a Course Through a Maze of Opportunities," Career Planning Workshop, Society for Mining, Metallurgy and Exploration (SME), 119th Annual Meeting of AIME, Salt Lake City, Utah, February 1990.

"Productivity Improvement through Quality Management," West Virginia Coal Mining Institute of America, White Sulfur Springs, West Virginia, November 1989.

"PRODUCTIVITY . . . Who is Responsible for Improving It?" Central Appalachian Section of AIME and NICOA Joint Meeting, Lexington, Kentucky, April 1989.

"Ethics and the State of the Industry," University of Kentucky Norwood Student Chapter of AIME, Lexington, Kentucky, 1987.

"Coal and the Environment," Indiana University of Pennsylvania Business Day IX, Indiana, Pennsylvania, 1986.

"Compliance with SMCRA in Pennsylvania," Society of Mining Engineers of AIME Off the Record Meeting, Pittsburgh, Pennsylvania, 1984.

"Economics of the Energy Industry," Armstrong-Indiana County Economic Education Foundation, Indiana, Pennsylvania, 1983.

"Ground Freezing as Used in the Excavation of a Mixed Face," with M.T. Wane, SME Fall Meeting, St. Louis, Missouri, 1970.

Jinrong Ma, Ph.D.

Education:

Doctor of Philosophy- Engineering Science
Southern Illinois University, Carbondale, Illinois, May 2005

Master of Science - Mining Engineering
Southern Illinois University, Carbondale, Illinois, December 2000

Bachelor of Science - Mining Engineering
LiaoNing Technical University, China, July 1996

Background:

2005 - Present	Mining Consultant Marshall Miller & Associates, Lexington, Kentucky
2001 - 2005	Project Coordinator / Research Assistant Department of Mining and Mineral Resources Engineering, Southern Illinois University, Carbondale, Illinois
1996 - 1999	Research Associate China Coal Research Institute, Beijing, China
1996 - 1997	Research Assistant (Cooperative program) China University of Mining Technology (CUMT) and CCRI, Beijing, China
1994 - 1996	Research Assistant Department of Mining Engineering, LNTU, LiaoNing, China

Memberships:

Society of Geologists and Mining Engineers (SGME), SIUC
Society for Mining, Metallurgy, and Exploration, Inc. (SME)
National Stone, Sand & Gravel Association (NSSGA)
American Composite Manufactures Association
Society of Manufacturing Engineers

Professional Experience:

2005 - Present

Mining consultant specializing in mining engineering (underground and surface), ground control, rock mechanics, end-of-mine (EOM) reclamation, slope stability, foundation design, civil infrastructure design, composite material engineering, and numerical simulation of various geotechnical and composite material engineering problems. Duties include providing consulting and engineering management services at client sites; and leading professionals in 1) analyzing valuations of mineral reserves and assets; 2) planning excavation and extraction of minerals including coal; and 3) designing structures and excavations in rock and soil. Past projects include coal mine roof rating, alternate roof bolting plan design, mining equipment application and performance evaluation, subsidence prediction and ground control, stabilization of weak floor strata, hard roof weakening, weak roof consolidation, design of artificial roof supports, longwall production analysis, and EOM reclamation cost assessments. Mr. Ma is fluent in Chinese and English.

Professional Experience: (Cont)

2001 - 2005	Specific projects include: (1) Production Cost Reduction through Efficient and Effective Roof Support: field time study, operation research, laboratory testing, field measurements, coal mine roof rating. (2) Development of Coal Combustion Byproducts-filled Utility Poles for Electric Utility Industry: CCBs-filled polymeric composite material development, statistical experimental designs, composite material characterization through ASTM tests, micro/macro-mechanics analysis, composite utility pole design, multi-objective optimization, finite element analysis, full size composite model pole testing, and field demonstration of the developed model pole. (3) Geotechnical Testing of Weak Floor Strata at Liberty Coal Mine in Illinois. (4) Development and Demonstration of a Pilot Scale Facility for Fabrication and Marketing of Lightweight-CCBs-Based Supports and Mine Ventilation Blocks for Underground Mines: crib design, development of CCBs-based grout material, design of crib element and its rebar reinforcement system, finite element analysis of the manufactured crib, laboratory testing of the crib element and full size crib structure, and field demonstration of the developed products. (5) Underground Placement of Coal Processing Waste and CCBs-Based Paste Backfill for Enhanced Mining Economics: evaluation of the backfilling effect, development of the 2D finite element models for partially backfilled underground mine opening, effect of backfilling on opening stability, upgrading SIU Panel3D to windows version using VB 6 and Junior Plot plug-in, and analysis of the effect of backfilling on panel stability. (6) Coal Mine Roof Rating and Geotechnical Investigation for Vermillion Grove Coal Mine: field and laboratory CMRR studies, laboratory testing of rock cores, alternative roof bolt plan design, etc. (7) Analysis of the Effects of Weak Floor Strata and Paleochannel on Longwall Face Ground Control. (8) Forecasting Time-Dependent Pressure and Shield Maintenance using Real-time Monitoring System.
1996 - 1999	Specific projects include: (1) Analysis and Development of an Expert System on Ground Control at Top-Coal-Caving Longwall Face: development of a longwall top-coal-caving ground control database, rules extraction using classification decision tree, and development of a database-oriented longwall face ground control expert system using Visual FoxPro 6.0 and Visual C++). (2) Advanced Roof Control Technology at Fully Mechanized Top-Coal-Caving Longwall Face: field core drilling, rock core description, core wrapping, uniaxial and triaxial compression tests, massive hard rock mass weakening techniques like localized micro-blasting, chemical softening, and pressurized water injection, an air-driven hole sealing system design, deep hole drilling and water injection in the field, field data collection and analysis, etc. (3) Immediate Roof Strata Control at Fully Mechanized Longwall Top-Coal-Caving Face: physical model simulation, 2D finite element modeling, analysis of the effect of various factors affecting weak roof stability at top-coal-caving longwall face, and roof consolidation operation in the field.
1996 - 1997	Post-graduate training on Elastic Mechanics, Statistics Methods, Engineering Rock-Mass Mechanics, Granular Medium Mechanics, Plastic Mechanics, etc.

Professional Experience: (Cont)

1994 – 1996	(1) A Study of Longwall Overburden Strata Movement using Physical Model Simulation: longwall physical simulation model (10:1 ratio), data acquisition system, data collection and analysis. (2) Field Investigation of the Effects of Overburden Strata Movement on Longwall Face Stability: field roof-floor convergence monitoring station setup, data collection and analysis. (3) A 0.9-million-ton Longwall Coal Mine Design for Gushan Mine No 2 Pit of Pingzhuang Coal Bureau: geologic and geotechnical data collection, drafting mine layout, panel layout design, tunneling method selection, production system design, longwall equipment selection, initial investment and operating costs estimation.
1993 – 1994	Practical Training: Geological survey, longwall mining operation, drill and blasting, roof bolting.
1992 – 1993	Summer Intern: Slope stability and failure control, coal spontaneous combustion control, drill and blasting, etc

Publications and Presentations:

Ma, Jinrong, Y. P. Chugh, etc., "Design and Analysis of Coal Combustion By-products-filled Fiberglass Reinforced Polymeric Composite Material for Utility Pole," Ph.D. Dissertation, Department of Mining and Mineral Resources Engineering, Southern Illinois University Carbondale, 2005.

Chugh, Y. P., W. Pytel, Jinrong Ma, "Development and Demonstration of an Alternate Geometry for Improved Ground Control in an Illinois Coal Mine," 23rd International Conference on Ground Control in Mining, Morgantown, West Virginia, 2004.

Chugh, Y. P., Jinrong Ma, "Coal Utilization Byproducts-based Artificial Supports – Recent Developments," 23rd International Conference on Ground Control in Mining, Morgantown, West Virginia, 2004.

Chugh, Y. P., Jinrong Ma, Samrat Mohanty, "An Analysis of the Stability of Partially Backfilled Coal Mine Layouts Underlain by Weak Floor Strata," 5th International Symposium on Mining Science and Technology, China University of Mining and Technology, Xuzhou, Jiangsu, P.R. China, 2004.

Ma, Jinrong, Y. P. Chugh, "Design and Analysis of Coal Combustion Byproducts (CCBs) Based Artificial Supports," 5th International Symposium on Mining Science and Technology, China University of Mining and Technology, Xuzhou, Jiangsu, P.R. China, 2004.

Chugh, Y.P., D. Biswas and Jinrong Ma, "Simplified Concept to Assess Stability of Partially Backfilled Mine Openings: Part 1 – Development," Transactions, Society for Mining, Metallurgy, and Exploration, Inc., Volume 314, pp 44-50, 2003.

Chugh, Y. P., G. Balk, Jinrong Ma, D. Biswas, "Design and Development of an Innovative Coal Utilization Byproducts- Based Crib Element for Underground Mine Support," 9th Annual International Pittsburgh Coal Conference, Pittsburgh, Pennsylvania, 2002.

Ma, Jinrong, Y. P. Chugh, "Finite Element Analysis Tutorial - Linear Stress Distribution Around 2-D Rectangular Mine Opening," Tutorial for MNGE431, MNGE511, and ENGR550K. Department of Mining and Mineral Resources Engineering, Southern Illinois University Carbondale, 2002.

Publications and Presentations: (Cont.)

Ma, Jinrong, D. Deb, Y. P. Chugh, "Analysis of the Effects of Weak Floor Strata on Longwall Face Stability Using Finite Element Modeling," Journal of Coal Science and Engineering (China), Vol. 7, No. 1, pp. 1 – 8, 2001.

Ma, Jinrong, Y. P. Chugh, D. Deb, "An Analysis of the Effects of Sandstone Channel in the Roof on the Longwall Face Stability Using Finite Element Method," Frontiers of Rock Mechanics and Sustainable Development in the 21st Century, Proceedings of the 2nd Asian Rock Mechanics Symposium, Beijing, China, pp. 385-393, 2001.

Ma, Jinrong, D. Deb, etc., "Numerical Analysis of the Effects of Weak Floor Strata and Paleochannel in the Roof on Longwall Face Stability," Masters Thesis, Department of Mining and Mineral Resources Engineering, Southern Illinois University Carbondale, 2000.

Ding, Rijia, Jinrong Ma, "The Simulation and Optimization of Development-Extension Plan at a Mine in China." The 4th International Symposium on Mining Science and Technology, Beijing, China, 1999.

Yan, Shaohong, Jinrong Ma, Yunce Fan, Shangling Liu, "Top Coal Control in the Face of a Soft Thick Coal Seam in Longwall Face with Top-Coal-Caving," 9th International Conference on Rock Mechanics, Paris, France, 1999.

Appendix C

Glossary of Terms

GLOSSARY OF TERMS

Abutment Load: In underground mining, the weight of rock above an excavation which has been transferred to the adjoining walls.

Bedding Planes: A separation or weakness between two layers of rock, caused by changes during the building up of the rock forming material.

Borehole: A hole with a drill, auger, or other tools for exploring strata in search of minerals, for water supply, for blasting purposes, for proving the position of old workings, faults, and for releasing accumulations of gas or water.

Breaker Post: Timbers, or posts set to break the roof off at a prearranged line during retreat mining, or when blasting down roof.

Bridge Conveyor: A conveyor which is supported at one end by a loading unit and at the other end by a receiving unit in such a way as to permit changes in the position of either end without interrupting the operation of the loading unit.

Btu: Abbreviation for British thermal unit. Heat needed to raise 1 pound of water 1 degree Fahrenheit.

Bump: Sudden failure of the floor or walls of a mine opening, generally accompanied by a loud report and a sharp shock or jar.

Cable Bolt: A device or method for reinforcing ground prior to mining. The basic cable bolt support consists of a high-strength cable installed in a borehole 4.12 to 6.35 cm in diameter and grouted with cement.

Cantilever: A lever-type beam that is held down at one end, is supported near the middle, and supports a load on the other end.

Chevron Pillar: A pillar having the shape of a V or an inverted V.

Clay Vein: A body of clay, usually roughly tabular in form like an ore vein, which fills a crevice in a coal seam. It is believed to have originated where the pressure was high enough to force clay from the roof or floor into small fissures and in many instances, to alter and to enlarge them. Also called horseback.

Coal Horizon: A layer in a coal profile.

Compressive Strength: The maximum compressive stress that can be applied to a material, such as a rock, under given conditions, before failure occurs.

Continuous Haulage: A process that is designed to move the mined product (usually coal) from a continuous mining machine to a mine belt conveyor system as a continuous flow. One end of the continuous haulage system (the outby end) always remains positioned so that it discharges onto the mine belt; the other end (inby end) is free to move as the mining machine advances so as to be able to receive the product from the machine's conveyor discharge.

Continuous Miner: A mining machine designed to remove coal from the face and to load that coal into cars or conveyors without the use of cutting machines, drills, or explosives.

Convergence: Loss of height when a coal seam is extracted as the roof lowers and the floor lifts. Convergence is an important factor in thin-seam mining.

Crosscut: In room-and-pillar mining, the piercing of the pillars at more or less regular intervals for the purpose of haulage and ventilation.

Cutter: Closed or inconspicuous seams along which rock may separate or break easily.

Discontinuity: An abrupt change in the physical properties of adjacent materials in the Earth's interior.

Draw Shale: A soft shale, slate, or rock approx. 2 in (5.08 cm) to 2 ft (0.61 m) in thickness, above the coal, and which falls with the coal or soon after the coal is removed.

Entry: An underground passage used for haulage or ventilation, or as a manway. Back entry, the air course parallel to and below an entry. Distinguished from straight entry, front entry, or main entry. Dip entry, an entry driven downhill so that water will stand at the face directly down a steep dip slope. Gob entry, a wide entry with a heap of refuse or gob along one side. Slab entry, an entry that is widened or slabbed to provide a working place for a second miner. Double entry, a system of opening a mine by two parallel entries; the air current is brought into the rooms through one entry and out through the parallel entry or air course. Cutoff entry, an entry driven to intersect another and furnish a more convenient outlet for the coal. Single entry, a system of opening a mine by driving a single entry only, in place of a pair of entries. The air current returns along the face of the rooms, which must be kept open. Triple entry, a system of opening a mine by driving three parallel entries for the main entries. Twin entry, a pair of entries close together and carrying the air current in and out, so laid out that rooms can be worked from both entries. Also called double entry.

Face: The surface of an unbroken coal bed at the advancing end of the working place.

Fault: A fracture or a fracture zone in crustal rocks along which there has been displacement of the two sides relative to one another parallel to the fracture. The displacement may be a few inches or many miles long.

Fender: A thin pillar of coal, adjacent to the gob, left for protection while driving a lift through the main pillar.

Floor Heave: A rising of the floor of a mine caused by its being too soft to resist the weight on the pillars.

Gob: That part of a mine from which the coal has been worked away and the space more or less filled up.

Horseback: See Clay Vein.

Inby: Toward the working face, or interior, of the mine; away from the shaft or entrance.

Interburden: Material of any nature that lies between two or more bedded ore zones or coal seams.

Kettle Bottom: A smooth, rounded piece of rock, cylindrical in shape, which may drop out of the roof of a mine without warning, sometimes causing serious injuries to miners. The surface usually has a scratched, striated, or slickensided appearance and frequently has a slick, soapy, unctuous feel. The origin of this feature is thought to be the remains of the stump of a tree that has been replaced by sediments so that the original form has been rather well preserved. Sometimes spelled kettlebottom. Also called bell; pot; camelback; tortoise; pot bottom.

Lift: A cut taken out of a pillar during retreat mining.

Mains: The principal entry or set of entries driven through the mine from which cross entries, room entries, or rooms are turned.

Outby: Nearer to the shaft, and therefore away from the face, toward the pit bottom or surface; toward the mine entrance. The opposite of inby.

Pressure Arch: The pressure arch theory in roof action suggests that, when a narrow heading is advanced, the layers of rock in the immediate roof deflect slightly and relieve themselves of the load of the overlying strata by transferring it to the sides of the opening by means of a pressure arch. The arch width just short of that which the higher strata cannot span and transfer the load to the sides of the opening is called the maximum-pressure arch. The depth mainly influences the minimum width of the pressure arch, although the type of overburden also plays a part. The following formula has been developed for approximating the minimum width of the maximum-pressure arch (W = minimum width of arch, in feet; D = depth of coal from surface, in feet): $W = 3[(D / 20) + 20]$. The equation does not apply for overburden less than 400 ft (122 m) or more than 2,000 ft (610 m) thick.

Rib: The side of a pillar or the wall of an entry.

Rider Seam: A thin coal seam above a workable seam, or a seam that has no name.

Roadway: An underground drivage. It may be a heading, gate, stall, crosscut, level, or tunnel and driven in coal, ore, rock or in the waste area. It may form part of longwall or room-and-pillar workings or an exploration heading. A roadway is not steeply inclined.

Roll: See Slough.

Roof Bolt: A long steel bolt inserted into walls or roof of underground excavations to strengthen the pinning of rock strata. It is inserted in a drilled hole and anchored by means of a mechanical expansion shell that grips the surrounding rock at about 4 ft (1 m) spacing and pins steel beams to the roof.

Scouring: An area where sandstone has eroded part of the coal seam.

Seismicity: Measure of frequency of earthquakes, for example, the average number of earthquakes per year and per 100 square miles.

Shuttle Car: A vehicle on rubber tires or continuous treads to transfer raw materials, such as coal and ore, from loading machines in trackless areas of a mine to the main transportation system.

Slickenside: The striations, grooves, and polish on joints and fault surfaces.

Slip: A joint or cleat in a coal seam.

Slough: Minor face and rib falls.

Spalling: The chipping, fracturing, or fragmentation, and the upward and outward heaving, of rock caused by the action of a shock wave at a free surface or by release of pressure.

Spars: Applied locally by miners to small clay veins found in coal seams.

Squeeze: The settling, without breaking, of a mine roof over a considerable area of workings. Also called creep; crush; pinch; nip.

Submains: Material of any nature that lies between two or more bedded ore zones or coal seams.

Subsidence: The sudden sinking or gradual downward settling of the Earth's surface with little or no horizontal motion. The movement is not restricted in rate, magnitude, or area involved. Subsidence may be caused by natural geologic processes, such as solution, thawing, compaction, slow crustal warping, or withdrawal of fluid lava from beneath a solid crust; or by human activity, such as subsurface mining or the pumping of oil or groundwater; bottom subsidence.

Tensile Strength: The maximum applied tensile stress that a body can withstand before failure occurs.

Tensile Stress: A normal stress that tends to cause separation across the plane on which it acts.

Tram: Generally, to move a self-propelled piece of equipment.

Turn: A curve into a pillar.

Working: When a coal seam is being squeezed by pressure from the roof and floor it emits creaking noises and is said to be "working." This noise often serves as a warning to miners that additional support is needed. Sagging roof emitting noises and requiring additional timbering.

Appendix D

Mobile Roof Support Operator's Guidelines

MOBILE ROOF SUPPORT OPERATOR'S GUIDELINES

The following text is intended to summarize guidelines for MRS Operators.

Roof falls remain a hazard during retreat mining even though the Mobil Roof Support unit (*MRS*) provides remotely controlled roof support. The area outby the pillar line is under permanent roof support. When the roof collapses during retreat mining, the fall is broken along the pillar line by posts, jacks, or MRS machines, which serve as breaker line supports. The movement of the roof material presents an unpredictable circumstance which demands extreme caution to avoid injury or death.

- Make sure you are familiar with all State and Federal laws that apply to the operation of these machines.
- Read, understand, and follow the current mining plan for your operating section or unit.
- Make sure all personnel, including yourself, are clear of the machine before starting.
- Never position yourself, or other personnel, between the machine and the rib, face or another piece of equipment.
- Personnel should remain at least 20 feet away from MRS units, when they are being pressurized or depressurized.
- Make sure all personnel, including yourself, are clear of the trailing cable before turning on the cable reel.
- Do not climb into the MRS.
- Always use remote controls for normal operation. The manual controls are provided only for maintenance and troubleshooting.
- Plans for performing maintenance in safe locations and for retrieving disabled or stuck MRS units should be formulated in advance and strictly followed.
- When moving in the working place, move the machines in pairs keeping one machine of each pair against the roof at all times. Then step out of the place by alternately lowering and setting the MRS units. Move the MRS one half a machine length in good roof; much less in broken roof, before resetting and moving the other MRS.
- When lowering the roof support plate from roof, first bring in all four cylinders down together then lower inby end of roof support plate to allow roof material to fall toward the gob line. In poor or broken roof, lower the end of the roof support plate closest to the gob line first.
- Allow at least one foot side to side spacing between the MRS units to avoid dragging the chain curtains.

- Position the roof supports as close to the continuous miner as possible during all lifts, especially during the final push-out.
- Set the MRS firmly against the roof at a pressure that will provide compression of the strata immediately above the seam.
- If caving of the roof is imminent, make sure the roof support plate is pressurized against the mine roof. Failure to do so may result in damage to the MRS and caving of the roof which overrides the supports.
- All personnel should be positioned outby the active intersection during the last lift of the retreat mining. If the final stump is recovered, four MRS units should be used, and two of them should be positioned to narrow the roadway through the intersection as much as possible.
- Upon completion of mining in a given pillar, the units should be moved sequentially until they are between solid coal. MRS should always be advanced sequentially such that one unit will never be offset more than one half the length of its companion unit. During this process, at least one unit should be pressurized against the roof at all times.
- Pressure gauges or load indicating lights should be visible from a distance, and if the yield pressure is reached, mining should cease in that lift.
- Never attempt to increase the output of the MRS units by adjusting the valving beyond its rated capacity.
- If there are any problems with the machines, report them to your supervisor immediately.

Reference: MRS Operator's Pocket Guide, JH Fletcher & Co., 1998

Appendix E

Geology Review Guidelines

GEOLOGY REVIEW GUIDELINES

The ability to identify geologic hazards underground is difficult even for the most experienced geotechnical engineer. Examination by visual means is often hampered by rock dust, poor visibility, and inadequate lighting. Knowledge of previous roof conditions at a mine either from borehole information or from underground roof bolt test holes, assists the local mine worker in identifying conditions that create hazards. The roof control plan should contain the following geology information at a minimum:

Section 16 Roof Control Plan Information

(4) A typical columnar section of the mine strata which shall:

a. Show the name and thickness of the coal bed to be mined and any persistent partings;
b. Identify the type and show the thickness of each stratum up to and including the main roof above the coal bed and the distance for at least 10 feet below the coal bed; and
c. Indicate the maximum cover over the area to be mined.

The Researchers found the geology information in the roof control plan to be too general to judge roof support requirements in several areas during retreat mining: high stress conditions, during removal of the pushout stump where barrier pillars exist in abandoned over/under seam mining, and where weak rock exists in the interburden. A single borehole may be representative of a mine's average roof condition, but may not reflect conditions in non-typical areas and additional geological information is necessary to determine the impact of certain mining practices. These guidelines are intended to provide a decision tree in reviewing geology requirements and when to inquire into additional information in reviewing retreat mining plans.

1) **<u>Identify the thickness of the immediate roof, that is the first strata, or groups of strata if there are several lithology changes, identified in the column.</u>**

a) Is the proposed minimum roof bolt length greater than the immediate roof?

i) If "Yes", is the roof bolt anchored at least 1 foot in competent strata (sandstone or sandy shale, or a continuous bed of uniform material)?

(a) If "Yes", then approve roof bolt length,

(b) If "No", request information or calculations demonstrating the roof bolt length will provide adequate support.

ii) If "No", request information or calculations demonstrating the roof bolt length will provide adequate support.

2) Is there overmining or undermining of the mine proposing retreat mining operations?

a) If "Yes", is the interval between the seams greater than or less than 100 feet?

i) If the interval is greater than 100 feet, move to question 3.

ii) If the interval is less than 100 feet, request:

(1) Interval isopach map showing the thickness contours (not more than 20 feet intervals) of the rock between the mine proposing retreat mining operations and the overlying or underlying seam(s). If both, then provide two separate maps.

(2) Identify areas in the overlying or underlying seam(s) where retreat mining or longwall mining has been carried out.

(3) Identify mined areas in the overlying seam where flooded zones exist.

(4) Provide borehole logs of nearest core or cores showing the type and thickness of the strata between the seams or mines. List the total thickness of strong rock (sandstones or sandy shales), weak rock (siltstones or claystones), or provide rock strength tests to demonstrate competency of interburden strata.

(5) Provide a description of mining practices or geology that will minimize interactions between the two seams, include a discussion of the following seam interactions, if applicable: high stress concentrations, water migration, gas migration, loss of ventilation, or collapse of the interburden.

b) If "No", move to question 3.

3) Does the proposed retreat mining plan include the removal of the pushout stump.?

a) If "Yes", what are the dimensions of the pushout stump pillar from the crosscut corner?

i) If the dimensions are less than the dimensions in the table below, request a description of additional factors or the rationale in leaving an undersized pillar for extraction and the support of the adjacent intersection.

Seam Height, ft	Corner-to-cut distance, ft
4	8.5
6	9.5
8	10
12	10.5

ii) Provide a columnar section from the nearest borehole, roof bolt test hole, or in mine drilling to define the type and thickness of the strata in the immediate roof.

iii) Define how the existing geology, permanent support or proposed supplemental support will minimize any degradation of roof stability in the intersection during and after the removal of the pushout stump.

iv) If supplemental support is specified, then supplemental support should provide a roof beam with the equivalent of 3 feet of anchorage of roof bolts or cable bolts into strong rock. Specify what types of supplemental roof bolts are used (length, pattern, etc.). Provide rationale why the supplemental roof bolts will support the intersection.

b) If "No", then additional geology information is not needed

Appendix F

MSHA – Best Practices Retreat Mining

Best Practices
Retreat Mining
BP Card No. 27

A review of fatal accidents that occurred during pillaring from 1989 through 1996 showed that:

Forty-two percent of fatalities occurred on the final push out or the last lift; and

Forty percent of the fatal accidents occurred while the approved mining sequence was not followed.

During the review, it was also discovered that:

Adverse geology contributed to more than forty of all retreat mining fatalities.

Most unintentional roof falls occur in July, August, September, October and November, with August having the most falls.

The best practices listed below should be followed during retreat mining.

- Know your approved roof control plan.
- Follow the safety precautions and mining sequence in the approved roof control plan. (The roof control plan is a **minimum** plan.)
- Additional supports, such as longer bolts, posts, cribs, crossbars, and metal straps, should be used at **any indication** of bad roof.
- Install breaker posts; they are the only supports that stand between you and the gob.
- Install radius turn posts and roadway posts; they make a safe road.
- Continually observe the breaker, radius and roadway posts to see if they are taking excessive weight (bending or breaking).
- Use only posts that are of proper size, and are installed on solid footing.
- While waiting between shuttle car runs, listen to and sound the roof.
- Stay outby the intersection if you don't have a job at the face.

U.S. Department of Labor
Mine Safety and Health Administration

- Never congregate near an active pillar line.
- Ensure that mechanical roof bolts are anchoring into at least 12 inches of solid strata.
- Drill test holes at least 12 inches deeper than the bolt being installed.
- Ensure that all draw rock is taken down or supported. Keep a slate bar of suitable length on the continuous miner and roof bolter for this purpose.
- Report all adverse roof conditions to the foreman.
- Always maintain proper stump and fender size.
- When mining the final push out, all persons, except haulage equipment and miner operators, should be located outby the immediate intersection.
- Do not mine the final push out if conditions do not look safe, or leave the stump if adverse conditions appear.
- Watch the mine floor conditions for evidence of heaving.
- Take special note of geologic conditions (slips, kettle bottoms) that did not adversely affect roof conditions during development. As stress in the roof from second mining increases, the influence and hazards of these conditions may increase.
- Carefully evaluate roof conditions in old areas where mechanical bolts were used for support. The anchorage of these bolts often deteriorate with time and new supports may be needed.
- In areas of high cover, pillar sloughing and the presence of fine, rust-colored dust at the top of the coal could be an indication of a concentration of stress which could be suddenly released.

Special practices for mines with shallow cover

- Take special precautions when approaching within 150 to 200 feet of the outcrop or when mine cover is less than 100 feet (check mine map).
- These special precautions should include additional roof support and reducing entry and crosscut width.
- Water dripping from the roof is an indication the roof strata has been fractured and weakened. Additional support may be needed.
- Special note should be taken of geologic conditions such as mud seams and vertical cracks in the roof.

Visit the MSHA home page at www.msha.gov

Appendix G

MSHA Training Material

MSHA TRAINING MATERIAL
(ROOF SUPPORT/GEOLOGIC HAZARDS)

Applicable

Roof and Rib Control (C)
Presents a broad over view of roof/rib hazards in the underground coal mining industry, and illustrates the need for roof and rib control. Topics covered in this video include roof and rib evaluations, the roof control plan, sources of roof/rib hazards, proper installation of roof supports, retreat mining, longwall mining, MRS units, ATRS units, information and technical support.
MSHA 2003 15 min
Cat No: VC 112
Price: $8.00

Don't Be the Fall Guy!
This book let is part of the PROP (Preventive Roof/Rib Outreach Program). It is designed to alert miners to the hazards presented in underground coal mining from falls of roof, face, and ribs. This booklet describes the sources of roof/rib hazards and provides practical information to avoid injuries from what has been historically the greatest danger to underground miners. Sources of technical assistance on roof control and other health and safety training resources are included.
MSHA 2000 25 pp
Cat No: OT 44
Price: Free of charge (1 book)
$2.00 (each additional copy)

Rock Falls – Preventing Rock Fall Injuries in Underground Mines (MNM)
This video demonstrates work procedures used by underground miners to detect unstable ground conditions and techniques to protect miners from injuries due to rock falls. It also demonstrates visual examination and sounding techniques, safe manual scaling procedures, and ground support systems. These techniques are shown through a typical mining cycle.
NIOSH 1999 20 min
Cat No: VC 981
Price: $8.00

Geology of Roof Falls (C)
Stresses the importance of noting changes in rock strata. Program follows a sequential change in roof rocks, and describes the changing roof conditions. Each fall area is described with colorful illustrations and photography to explain how weaknesses in the roof rock contributed to the falls.
NOTE: ***This video is a taped version of the slide-tape program.***
MSHA 1987 20 min
Cat No: VC 941
Price: $8.00

Requires Update

Trouble-Shooting Guide for Roof Support Systems, A
Provides a logical sequence to resolving the most common problems encountered with roof supports.
MSHA 1996 104 pp
Cat No: IR 1237
Price: Free of charge

REAP — Roof and Rib Fatalities — Coal
These videos discuss the Roof and Rib Fatalities for 1992-1994, and classify each fatality under one of three general causes:
1. Failure to comply with the approved roof control plan;
2. Failure of the roof control system; and
3. Traveling or working inby supported roof.

MSHA 15 min each
Cat No: VC 849 (1992)
VC 825 (1993)
VC 876 (1994)
Price: $8.00 each title

Supervisor's Responsibilities in Roof Control (C)
Helps frontline underground coal mine supervisors understand what their duties are to the miners, as well as to management, concerning safety in the working place.
MSHA 1988 11 min
Cat No: VC 919
Price: $8.00

Roof and Rib Fall Accident Statistics, An Overview of (C)
Designed to examine past and current roof and rib fall accident trends, and costs involved. By analyzing these trends it will present a clearer picture as to what areas of the mining cycle and work place need to be examined further, and indicate what has to be done to reduce the physical and financial damage that result from such accidents.
NOTE: ***This video is a taped version of the slide-tape program.***
MSHA 1988 15 min
Cat No: VC 942
Price: $8.00

Roof and Rib Control (C)
Examines the nature of a mine roof and describes measures that can be taken to minimize the danger of roof and rib falls in underground mines.
MSHA 1982 113 pp
Cat No: PI 3
Price: Free of charge (1 book)
$4.00 (each additional copy)

Why Roof Control Plans (C)
Roof and rib falls are still the most dangerous hazard an underground coal miner faces. The premise of this film is that the hazard can be prevented or reduced by following an approved roof control plan. Explains basic plans, gives examples and describes plan implementation. Demonstrates important items included in the plan (such as types of support, areas covered and rock strata diagrams) under actual mining conditions. Shows mining equipment and materials, bolting machines, roof bolts and timbers in use. Urges miners to become familiar with their mine's roof control plan.
MSHA 1981 16 min
Cat No: VC 874
Price: $8.00

Coal Mine Roof and Rib Control
Manual covers the most dangerous hazard to underground coal miners – fall of roof and ribs. Describes geology of coal and rock strata. Explains effects of mining on strata. Covers methods of support and roof control plans. Gives some coverage to inspection and testing of roof and ribs and prevention of roof and rib fall accidents.
MSHA 1980 49 pp
Cat No: SM 18
Price: Free of charge (1 book)
$2.00 (each additional copy)

Roof Bolting in Coal Mines
Stresses the importance of roof bolting to the coal mining industry. Explains principles and purposes of roof bolting. Uses working models, laboratory demonstrations, actual underground applications and tests. Shows how mining operations and bolting methods are coordinated and emphasizes safety throughout the roof control process.
BuM 1973 19 min
Cat No: VC 808
Price: $8.00

Role Play

Bull's Double Header: Too Much Unsupported Roof (C)
You work at a mine that has approval to make 34-foot cuts using a remote-controlled continuous miner. The roof bolting machine has broken down. The continuous miner has just been refitted with a new cutting head and bits that cut the coal much faster. The two roof bolter operators have been having a hard time keeping up with Bull, the continuous miner operator. At the face of No. 4 entry, Bull makes a 40-foot extended cut, trams back from the face, and then turns the miner and cuts the left-hand crosscut all the way through to the No. 3 entry. When the roof bolter operators discover Bull's "double header," they get the section foreman, and then try to plan a safe way to bolt this large area of unsupported roof. Shortly after they complete their assessment and plan of attack, a large roof fall occurs. Now the face crew must decide how to safely clean up the fall while advancing roof support.
Audience:
Underground coal miners
Materials needed:
Instructor's copy
Problem booklet - 1 for each trainee, may be duplicated from the Instructor's copy Answer sheets may be duplicated from the instructor's copy.
Optional - overhead projector and overheads of the diagrams found in the problem booklet and the answer key found in the Instructor's copy
Cat No: NI 11
Price: Instructor's Copy $2.00 each
Problem Book let $1.00 each
Answer Sheet $1.00 each

Pete's Predicament: Unsupported Roof (C)
The pre-shift examination has been completed. The entire section has been rock dusted. John and Eddy advance the miner to the face of the No. 3 entry and begin cutting coal. Pete is standing near the right rib watching the mining machine to observe its new water spray system. A shuttle car comes up close to the right rib. After watching the miner cut coal for less than a minute, Pete starts to get worried that he is in danger of being squeezed between the continuous miner and the rib. He steps back around the corner into the right-hand cross cut which is rock dusted. Then he notices that half the cross cut is unbolted and the top is dribbling small pieces of shale! Pete cannot escape into the No. 3 entry because the miner tailboom and shuttle car block this route. He sees that the far end of the cross cut is bolted. Pete must decide what to do to escape and to warn Eddy, John, and the shuttle car operator who are inby an unbolted crosscut. After Pete and Eddy escape, John must decide whether to abandon the mining machine and make a run for safety or to stay in the miner operator compartment under the canopy.
Audience:
Underground coal miners
Materials needed:
Instructor's copy
Problem booklet - 1 for each trainee, maybe duplicated from the Instructor's Copy
Answer sheets may be duplicated from the Instructor's copy
Cat No: NI 44

Price: Instructor's Copy $2.00 each
Problem Book let $1.00 each
Answer Sheet $1.00 each

Roof Control at Intersections Exercise (C)
Two underground coal miners are asked to advance the power center, mobile equipment, and trailing cables in the working section. While surveying their assignment, they notice coal spalling along the left rib of the belt entry. They must investigate and determine if a problem exists with roof and rib conditions and the diagonal measurements of several intersections. They are to take any corrective actions that might be necessary.
Audience:
Underground coal miners
Materials needed:
Instructor's copy
Problem book let - 1 for each trainee, maybe duplicated from the Instructor's copy
Answer sheet - 1 for each group of 3 to 5 persons working the exercise
Developing pens - 1 for each answer sheet
Information may be obtained from Bobbie Calhoun: phone 412-386-5901, fax 412-386-5902 or email minetraining@cdc.gov
Optional - overhead projector and overheads of the Master Answer Sheet and Scoring Key found in the Instructor's copy
Cat No: NI 54
Price: Instructor's Copy $2.00 each
Problem Book let $1.00 each
Answer Sheet $1.00 each

Roof Fall Entrapment (C)
A group of miners are extracting pillars in an unsafe manner. There is only one escapeway from the area where they are working. Earlier roof falls have blocked the other escapeways. The top is bad in the one entry being used for the haulroad. The posts and cross bars that support it at the intersection of a crosscut begin to sag so much that the shuttle car you are driving can't come out from the face. The foreman yells at you to tell the miners to get out. But it is too late! As you are about to come out there is a large roof fall that completely blocks the one escapeway. You and the other miners are lucky. No one is hurt, but now you must decide what to do.
Audience:
Underground coal miners
Materials needed:
Instructor's copy
Problem booklet - 1 for each trainee, may be duplicated from the Instructor's copy
Answer sheet - 1 for each group of 3 to 5 persons working the exercise
Developing pens - 1 for each answer sheet
Information maybe obtained from Bobbie Calhoun: phone 412-386-5901, fax 412-386-5902 or email minetraining@cdc.gov
Optional - overhead projector and overheads of the Master Answer Sheet and Scoring Key found in the Instructor's copy
Cat No: NI 55

Price: Instructor's Copy $2.00 each
Problem Booklet $1.00 each
Answer Sheet $1.00 each

Roof Support in a Primary Escapeway (C)
[Previously called D. R. Light]
On a recent run of the escapeways, the section boss notices that the brow of a high fall area has begun to deteriorate. On this particular day, the face boss asks the miner operator and helper to follow the escapeway out from the face and take down any loose top at the high fall area. After correcting this problem the workers encounter another hazardous roof condition nearby. This involves deterioration of the immediate roof around the bolt heads as a result of moisture in the mine air.
Audience:
Underground coal miners
Materials needed:
Instructor's copy
Problem booklet - 1 for each trainee, maybe duplicated from the Instructor's copy
Answer sheet - 1 for each group of 3 to 5 persons working the exercise
Developing pens - 1 for each answer sheet
Information may be obtained from Bobbie Calhoun: phone 412-386-5901, fax 412-386-5902 or email minetraining@cdc.gov
3-D reels - one reel for each person in the class
Viewmaster 3-D viewers - may be purchased

Sammy's Loose Roof Decisions (C)
[Previously called Sammy Spadd]
During your routine survey work as a transitman, you observed in recent weeks that an idle section in 2 North mains, about 3 miles from the portal, has been experiencing serious roof problems. One of the mine engineers stated that the problems were due to the sudden presence of slips in the roof running in the direction of mining. Several falls and significant down time have forced the company to reconsider the development of 2 North. The general superintendent informs you and Sammy that the company will reactivate the idled section beginning next shift. You are to enter the mine and set sights in 2 North to reorient all the entries by 45 degrees to the east before the regular day light crew arrives. You are beginning your work when you notice a section of top lower than the surrounding area. You must decide whether this is a problem that can wait or if it should be taken care of immediately.
Audience:
Underground coal miners
Materials needed:
Instructor's copy
Problem booklet - 1 for each trainee, maybe duplicated from the Instructor's copy
Answer sheet - 1 for each group of 3 to 5 persons working the exercise
Developing pens - 1 for each answer sheet
Information may be obtained from Bobbie Calhoun: phone 412-386-5901, fax 412-386-5902 or email minetraining@cdc.gov
3-D reels - one reel for each person in the class

Viewmaster 3-D viewers - may be purchased from your local toy store or purchased directly from the manufacturer at Fisher-Price, Inc., Viewmaster Custom Sales, Customer Service, 636 Girard Avenue, East Aurora, NY 14052, phone 716-687-3899
Optional - overhead projector and overheads of the Master Answer Sheet and Scoring Key found in the Instructor's copy
Cat No: NI 58
Price: Instructor's Copy $2.00 each
Problem Booklet $1.00 each
Answer Sheet $1.00 each
One "3-D Reel" $2.00 each

Unsupported Roof Rescue (C)
[Previously called Marvin R. Letcher]
You are the pinner operator. Your helper, Marvin, goes under unsupported roof. As you yell to him to get back, there is a roof fall. It catches Marvin's legs. He is lying face down and screaming. The roof is dribbling across the whole entry. You must figure out how to rescue and help Marvin without getting yourself or other miners injured.
NOTE: *This exercise is similar to* ***Highwall Rescue*** *de signed for surface miners. A companion,* ***Unsupported Roof Rescue*** *role play, is also available.*
Audience:
Underground coal miners
Materials needed:
Instructor's copy
Problem booklet - 1 for each trainee, may be duplicated from the Instructor's copy
Answer sheet - 1 for each group of 3 to 5 persons working the exercise
Developing pens - 1 for each answer sheet
In formation may be obtained from Bobbie Calhoun: phone 412-386-5901, fax 412-386-5902 or email minetraining@cdc.gov
Optional - overhead projector and overheads of the Master Answer Sheet and Scoring Key found in the Instructor's copy
Cat No: NI 70
Price: Instructor's Copy $2.00 each
Problem Booklet $1.00 each
Answer Sheet $1.00 each

Unsupported Roof Rescue (C) - Role Play
[Previously called Marvin R. Letcher role play]
You are the pinner operator. Your helper, Marvin, goes under unsupported roof. As you yell to him to get back, there is a roof fall. It catches Marvin's legs. He is lying face down and screaming. The roof is dribbling across the whole entry. You must figure out how to rescue and help Marvin with out getting yourself or other miners injured. You have slate bars, roof jacks, a mine first aid kit, a mine phone, and two other miners who can help. Your rescue and first aid performance will be rated against a check list by the instructor and your classmates.
NOTE: *This role play version provides hands-on practice of the first aid skills involved in the* ***Highwall Rescue Exercise*** *and* ***Unsupported Roof Rescue*** *exercises.*

Audience:
Underground coal miners
Materials needed:
Instructor's copy
Answer sheet - 1 for each trainee, may be duplicated from the Instructor's copy
Cat No: NI 71
Price: Instructor's Copy $2.00 each
Answer Sheet $1.00 each

Eyewitness Accounts

It Can Happen to You (C)
Even with all required roof protection in place, roof falls still can happen. This video stresses the importance of always being aware of your work environment and the ever changing conditions. You will hear from two survivors of roof fall accidents, one a roof bolter, and the other a continuous miner operator.
MSHA 2001 14 min
Cat No: VC 962
Price: $8.00

Protective Canopy (A Survivor's Story)
A taped interview with a roof fall survivor who was operating a scoop with a protective canopy. The miner tells in his own words how he survived after mine roof, approximately 4 feet thick; fell on the scoop he was operating, trapping him for at least 20 minutes. Taped on location in Madisonville, Kentucky.
MSHA 1995 6 min
Cat No: VC 894
Price: $8.00

Roof Fall Entrapment: Eye Witness Accounts (C)
Three miners who either witnessed or were involved in a roof fall accident discuss their experiences, thoughts and renewed respect for complying with safe work procedures and maintaining roof support systems. These video tapes are designed to motivate miners to be more aware of roof conditions and to comply with roof control plans. This program consists of three (3) video, one for each interview, with accompanying instructions to promote interaction of the viewers.
MSHA 1992
Title/Catalog No.
Eyewitness Accounts:
Dave Garry (VC 865) 15 min
Larry Strayer (VC 866) 14 min
Dave Murone (VC 867) 10 min
Price: $8.00 each title

Roof Fall Entrapment: Survivors' Accounts (C)
Two miners who were involved in a roof fall accident discuss their experiences, thoughts, and renewed respect for complying with safe work procedures and maintaining roof support systems. These videotapes are designed to motivate miners to be more aware of roof conditions and to comply with roof control plans. This program consists of two interviews on one videotape.
MSHA 1993
Cat No: VC 837
Survivors' Account:
Donzil Cutlip 13 min
Larry Clevenger 14 min
Price: $8.00

Incidental

Scaling
Scaling, the taking down of loose material from the roof, face and rib in hard rock mining. This videotape will remind you of some of the safety procedures and commonsense practices to use during scaling.
MSHA 1996 10 ½ min
Cat No: VC 836
Price: $8.00

Inby Roof Support
This video explores the myths/excuses miners use for going inby supported roof.
MSHA 1995 12 min
Cat No: VC 811
Price: $8.00

Cabs and Canopies for Your Safety (C)
Points out need for cabs and canopies on underground mining equipment to protect miners from falls of roof and ribs. Uses scenes taken after three actual roof fall accidents (in which fallen coal and rock covered the mining equipment). Demonstrates that, in each case, the operator escaped unharmed because of the protective canopy on the machine. Presents in-the-mine interviews with the operators involved in these near-fatal accidents – workers relate what happened and why they are convinced the canopies saved their lives.
MESA 1974 10 min
Cat No: VC 854
Price: $8.00

Appendix H

MM&A Statement of Qualifications

MARSHALL MILLER & ASSOCIATES, INC.

Energy • Environmental • Engineering

STATEMENT OF QUALIFICATIONS

Marshall Miller
Chairman of the Board and
Chief Executive Officer

"With regard to the advanced engineering and geological technologies, we fully expect to be the industry's primary source for harnessing the most depth and highest level of engineering and geological experience, education, and expertise. We also expect to house the most advanced hardware, software, and specialized equipment that the industry can call on. Throughout our history, we have never hesitated to invest in the coal industry and the technology that the industry needs. After 30 years of sustained investment in people, facilities, and increased capabilities, we are looking forward to the new millennium and the strategic support role we will play for the coal industry. We fully do plan and expect to be the industry's largest and most technically advanced consulting firm for engineering, geological, and environmental expertise and support."

Marshall Miller & Associates, Inc. (MM&A), maintains headquarters in Bluefield, Virginia. The multi-building complex, expanded 10 times over the last 15 years, houses one of the largest and most advanced technical centers in the eastern United States. Our Bluefield campus contains the main offices for our environmental, civil, geotechnical and marketing operations.

Our 11 branch offices are geographically distributed across eight states to allow for cost-effective mobilization to the Mid-Atlantic region.

Background

Founded in 1975 by Marshall S. Miller, current Chairman and CEO, the Bluefield, Virginia, company's roots are deeply entrenched in the coal mining industry of Appalachia. For over 30 years MM&A, has strived to be the best in its field, for both clients and employees. By cultivating a talented and diverse workforce dedicated to our clients' success, as well as personal achievement, we have created an atmosphere of collaboration, excellence and quality.

From humble beginnings in Marshall's garage to a 200+ employee firm spread throughout ten branch offices in eight states, MM&A has grown into a successful company focused on dedication to clients and the pursuit of excellence.

Purpose

Our mission is simple: to be something extraordinary to our clients. We accomplish this by recruiting talented employees who desire to not only perform their jobs well, but also desire to constantly improve. This dedication to a job well done is reflected in our level of service to our clients, which is our first and foremost concern.

We believe in personal and professional growth in our employees, which directly benefits our clients. By encouraging continuing education, providing on-the-job training, and identifying potential growth opportunities we have developed a knowledgeable and experienced staff capable of providing excellent service to our clients.

Ethics

MM&A adheres to a strict code of ethics in all that we do. We insist upon honesty and integrity from all of our employees, vendors and contractors, and we approach our clients and their projects with the utmost respect.

Through dedication to integrity in all of our tasks we can assure our clients that all aspects of their projects are conducted fairly, honestly and efficiently. This results in the achievement of our primary goal: quality, cost effective solutions for our clients delivered with a level of service unparalleled in our industry.

Looking Forward

As we experience expansion in our service offerings to meet client demands, we continually endeavor to identify new and better ways to serve our existing clients while developing relationships with new clients. With the addition of several new service areas we have also experienced growth in our staff, our skills, and our vision for the company.

Throughout our growing stages one thing remains unchanged: our dedication to serving our clients to the best of our ability. We promise our clients only what can be delivered, and then deliver more than promised.

MARSHALL MILLER & ASSOCIATES

What We Do

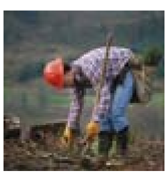
MM&A performs a wide range of geological, environmental, hydrogeological, and mining engineering services. Committed to achieving the highest standards in energy and mineral resources analysis and support services, MM&A's staff of over 100 professional geologists, hydrogeologists, mining and civil engineers, and geotechnical engineers works in tandem with clients to identify needs, analyze opportunities and prevent problems.

Geological Services
MM&A's scientists and engineers possess extensive knowledge and experience in reserve evaluation, database and property management, geotechnical evaluation, mine evaluation and hazard predictions, and field exploration/core descriptions.

Hydrology
Our professional hydrogeologists have extensive backgrounds in mine and quarry hydrogeology, providing clients with a variety of services ranging from operations monitoring to water supply development.

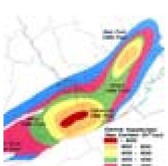
Mine and Quarry Permitting
MM&A's staff of professional geologists and engineers possesses extensive knowledge and experience in a variety of mine and quarry permitting regulations and compliance situations.

Synfuel
Since 1998 we have participated in numerous synfuel-related projects, serving in diverse capacities ranging from production tests to plant start-up and relocation certificates.



Sustainable Development
The sustainability concept is growing in popularity due to rising environmental concern in both the public and private sectors. We provide a full range of services directed toward designing, implementing, promoting, and managing effective sustainability projects.

Support Services
MM&A's Marketing & Communications Group (M&C) provides a broad range of advertising, marketing, public relations and IT services.

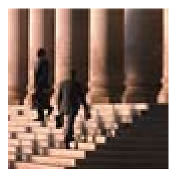


Coalbed Methane Evaluation
MM&A's geologists have extensive experience in the determination of coalbed methane quantity, quality, reservoir characteristics, and recovery technology.

Mining Engineering
MM&A provides specialized services related to mining engineering issues, including mine operations evaluation, valuation services, mine cost/cash flow analysis, mine planning, and construction services.

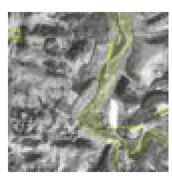
Environmental
Our staff of scientists and engineers provides Phase I ESA's, reclamation liability determination, mining reclamation and permitting, and mine drainage assessments.

Petroleum Engineering/Oil & Gas
MM&A offers economic analysis, well test design and interpretation, reserves estimation, and more.



Expert Witness
MM&A is a member of the Eastern Mineral Law Foundation, and our professionals routinely provide expert witness services for both private industry and state and federal government agencies.

Laser Mapping
Laser mapping and scanning showcases visible items and features that have been digitally recorded, delivering accurate applications for stockpile surveys, GPS surveying, and topographic scanning.



Geographic Information Systems
Geographic information is a strategic resource, essential to making informed decisions.

MARSHALL MILLER & ASSOCIATES

Office Locations

Headquarters

Route 720, Bluefield Industrial Park
P.O. Box 848
Bluefield, Virginia 24605
(276) 322-5467 • FAX (276) 322-3102
Email:
corp@mma1.com
http://www.mma1.com

MM&A's headquarters are located in Bluefield, Virginia, and occupy a multi-building complex that has been expanded 10 times over the last 30 years in order to house one of the largest and most advanced technical centers in the eastern United States. The main Bluefield office complex consists of several buildings that house environmental, civil, geotechnical and mining engineering departments; a soils laboratory; a geophysical operation center (Geological Logging Systems); a geological department; and drafting and graphics studios. This operation consists of 38,034 total square feet of office and lab space on 10 acres of land in the Bluefield Industrial Park.

MM&A's branch offices are geographically distributed to allow for cost effective mobilization to the Mid-Atlantic region. Each of the company's branch offices is fully staffed with experienced environmental professionals and civil engineers.

VIRGINIA
Suite 203, 11277 Airpark Road
Ashland, VA 23005
TEL (804) 798-6525
FAX (804) 798-5907

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Lexington, KY 40509
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FAX (859) 263-2839

KENTUCKY
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Madisonville, KY 42431
TEL (270) 825-4010

WEST VIRGINIA
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Charleston, WV 25301
TEL (304) 344-3970
FAX (304) 344-3986

WEST VIRGINIA
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WEST VIRGINIA
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Kingsport, TN 37663
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FAX: (423) 279-9777

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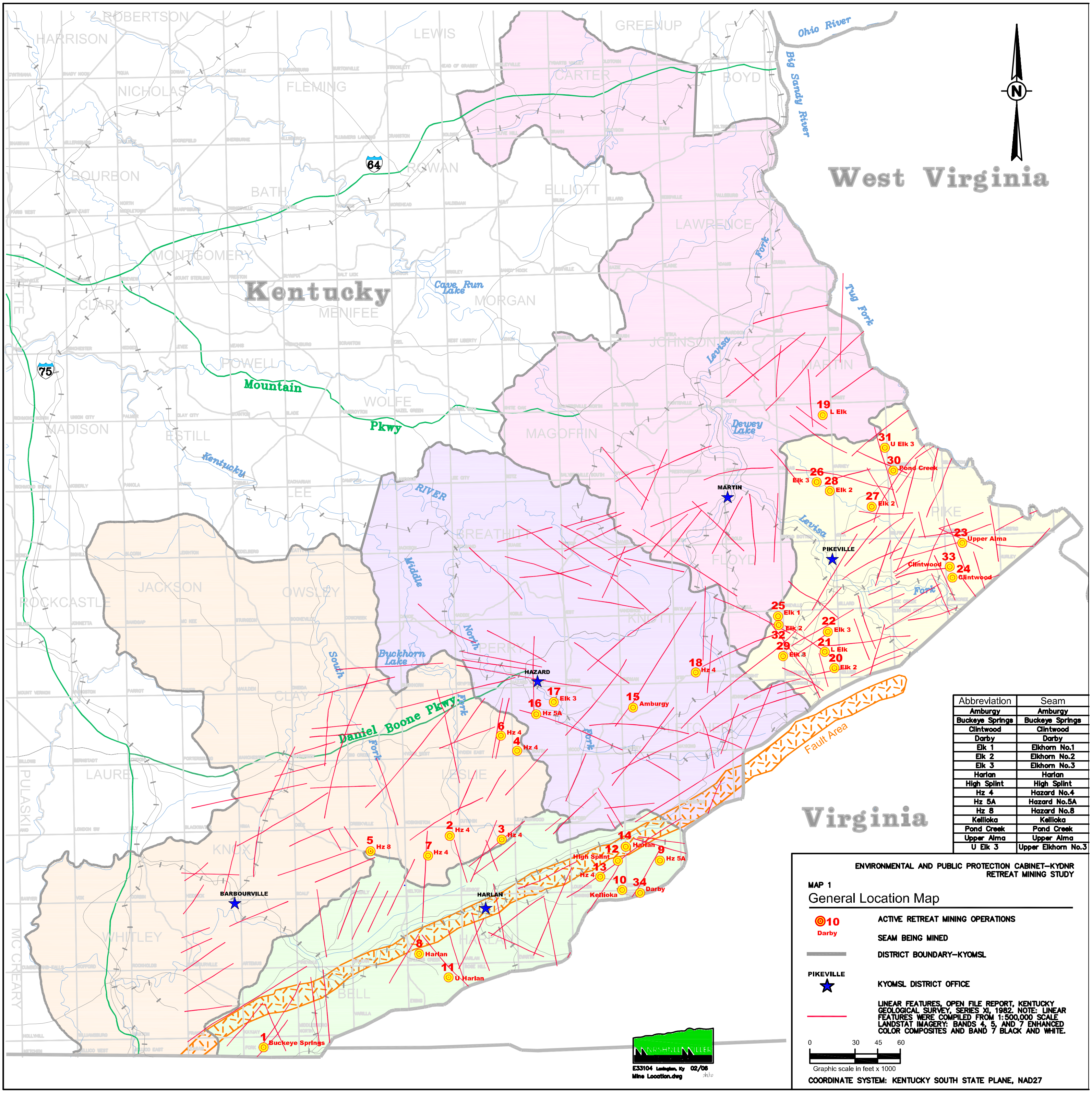
3913 Hartzdale Drive,
Suite 1306
Camp Hill, PA 17011
TEL (717) 730-7810
FAX (717) 730-7812

KANSAS
8371 Melrose Drive
Lenexa, KS 66214
TEL (913) 648-4424
FAX (913) 648-4763

LOUISIANA
1917 Pluto Drive
Bossier City, LA 71112
TEL: (318) 747-7734
FAX: (318) 747-7786

MARSHALL MILLER & ASSOCIATES

Map



Abbreviation	Seam
Amburgy	Amburgy
Buckeye Springs	Buckeye Springs
Clintwood	Clintwood
Darby	Darby
Elk 1	Elkhorn No.1
Elk 2	Elkhorn No.2
Elk 3	Elkhorn No.3
Harlan	Harlan
High Splint	High Splint
Hz 4	Hazard No.4
Hz 5A	Hazard No.5A
Hz 8	Hazard No.8
Kellioka	Kellioka
Pond Creek	Pond Creek
Upper Alma	Upper Alma
U Elk 3	Upper Elkhorn No.3

ENVIRONMENTAL AND PUBLIC PROTECTION CABINET–KYDNR
RETREAT MINING STUDY

MAP 1

General Location Map

10 Darby — ACTIVE RETREAT MINING OPERATIONS

SEAM BEING MINED

DISTRICT BOUNDARY–KYOMSL

PIKEVILLE — KYOMSL DISTRICT OFFICE

LINEAR FEATURES, OPEN FILE REPORT, KENTUCKY GEOLOGICAL SURVEY, SERIES XI, 1982. NOTE: LINEAR FEATURES WERE COMPILED FROM 1:500,000 SCALE LANDSTAT IMAGERY: BANDS 4, 5, AND 7 ENHANCED COLOR COMPOSITES AND BAND 7 BLACK AND WHITE.

0 30 45 60

Graphic scale in feet x 1000

COORDINATE SYSTEM: KENTUCKY SOUTH STATE PLANE, NAD27